Sheet Metal Industries

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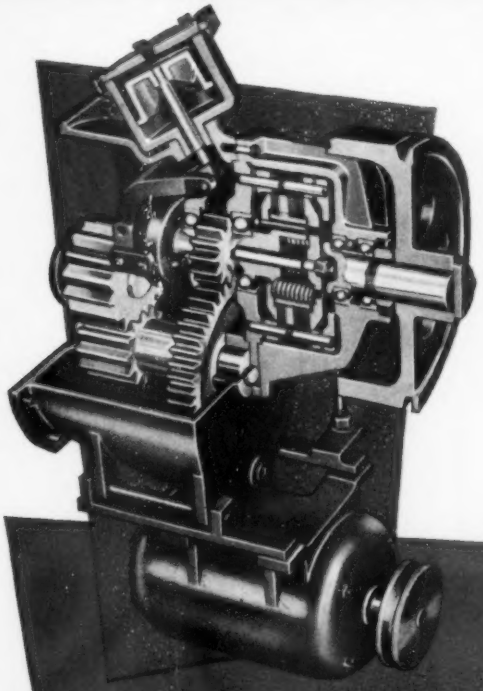
VOL. 38 : No. 410 JUNE 1961 PRICE 2/6



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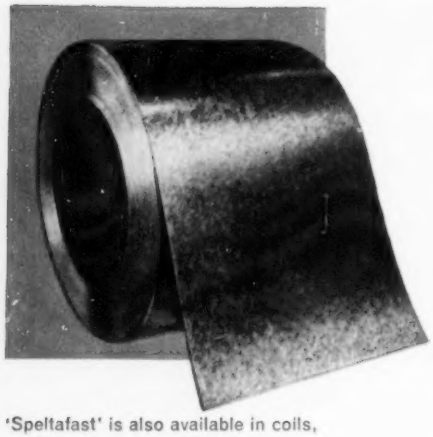

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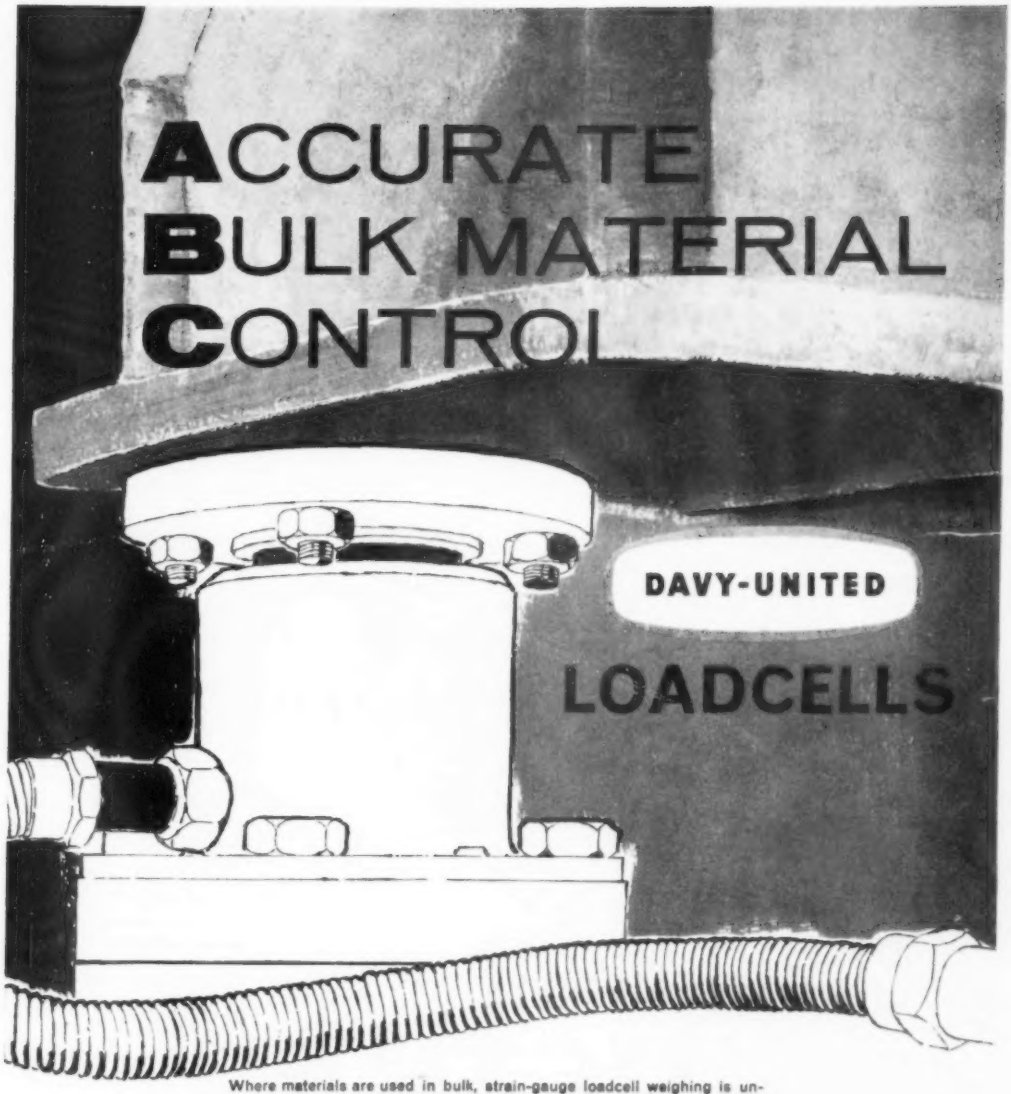

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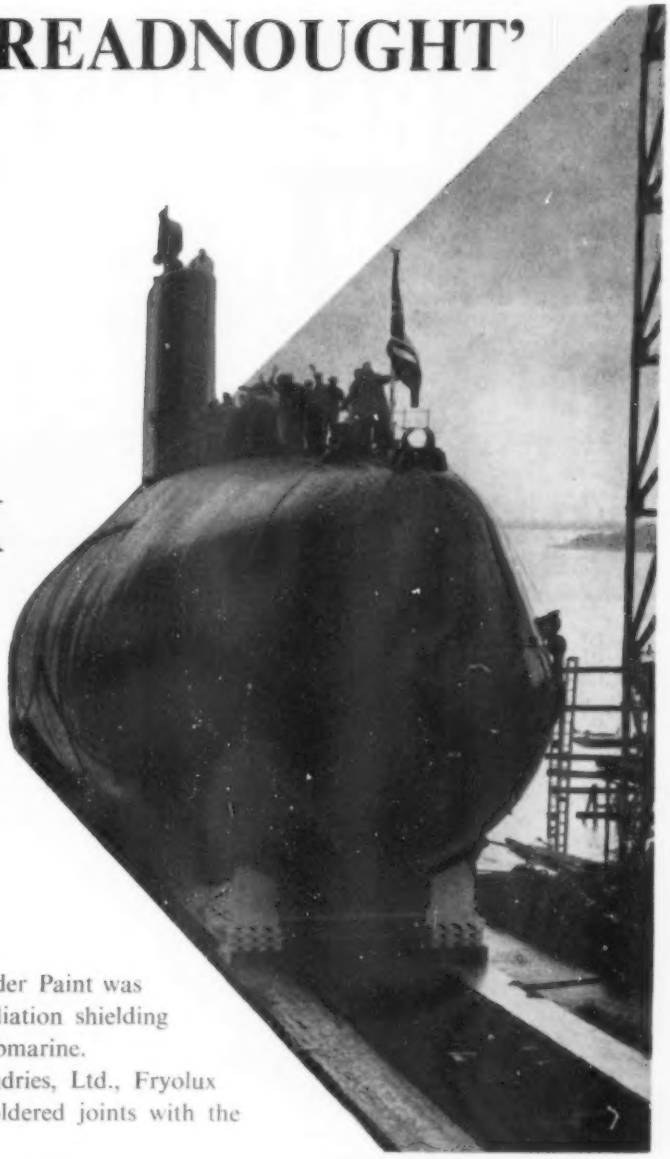

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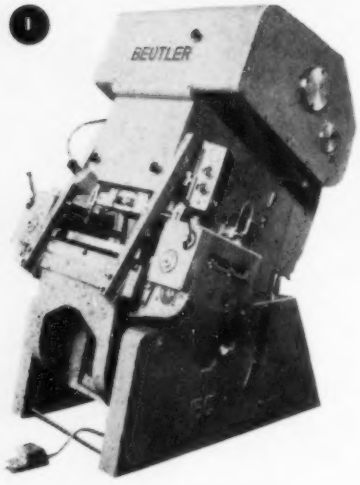

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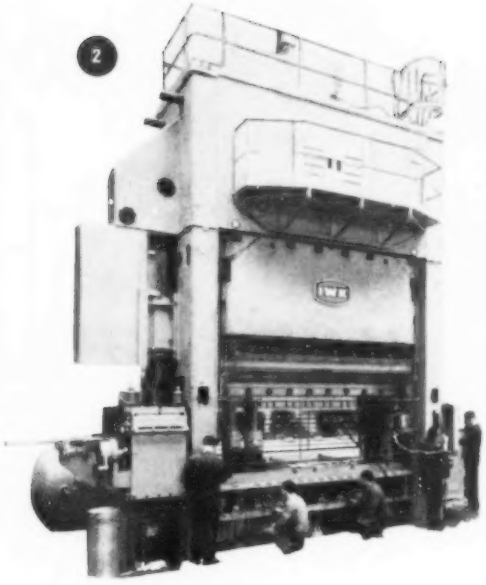

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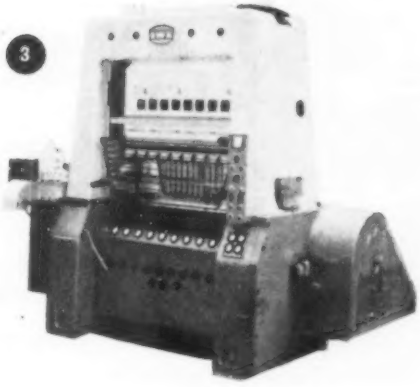

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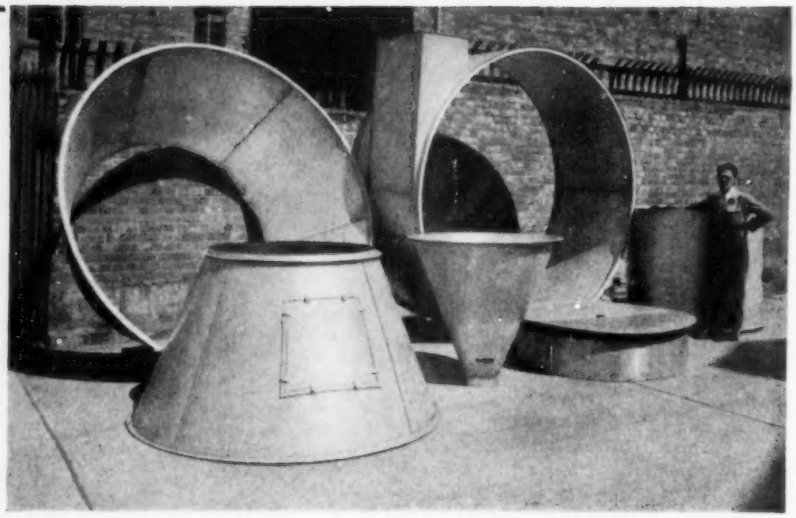

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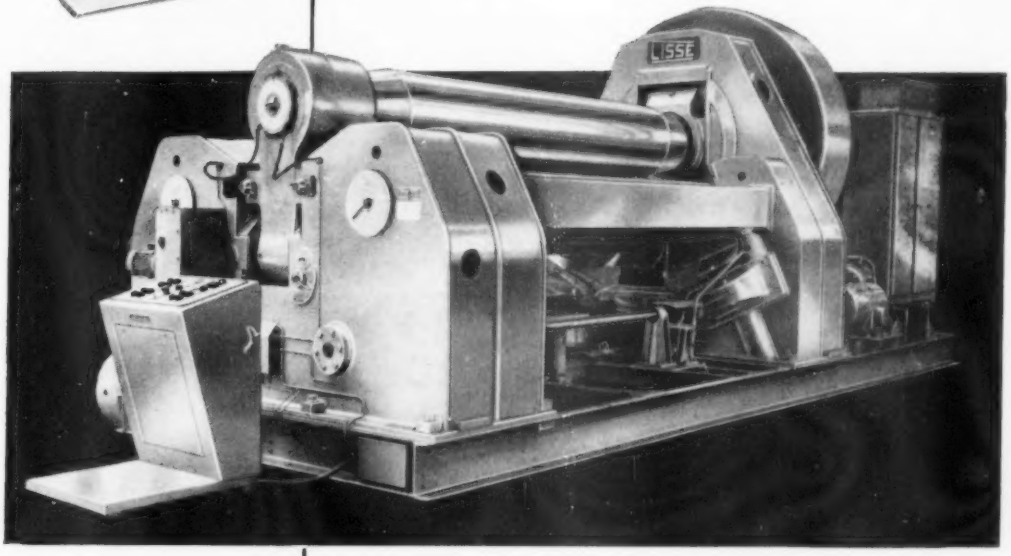

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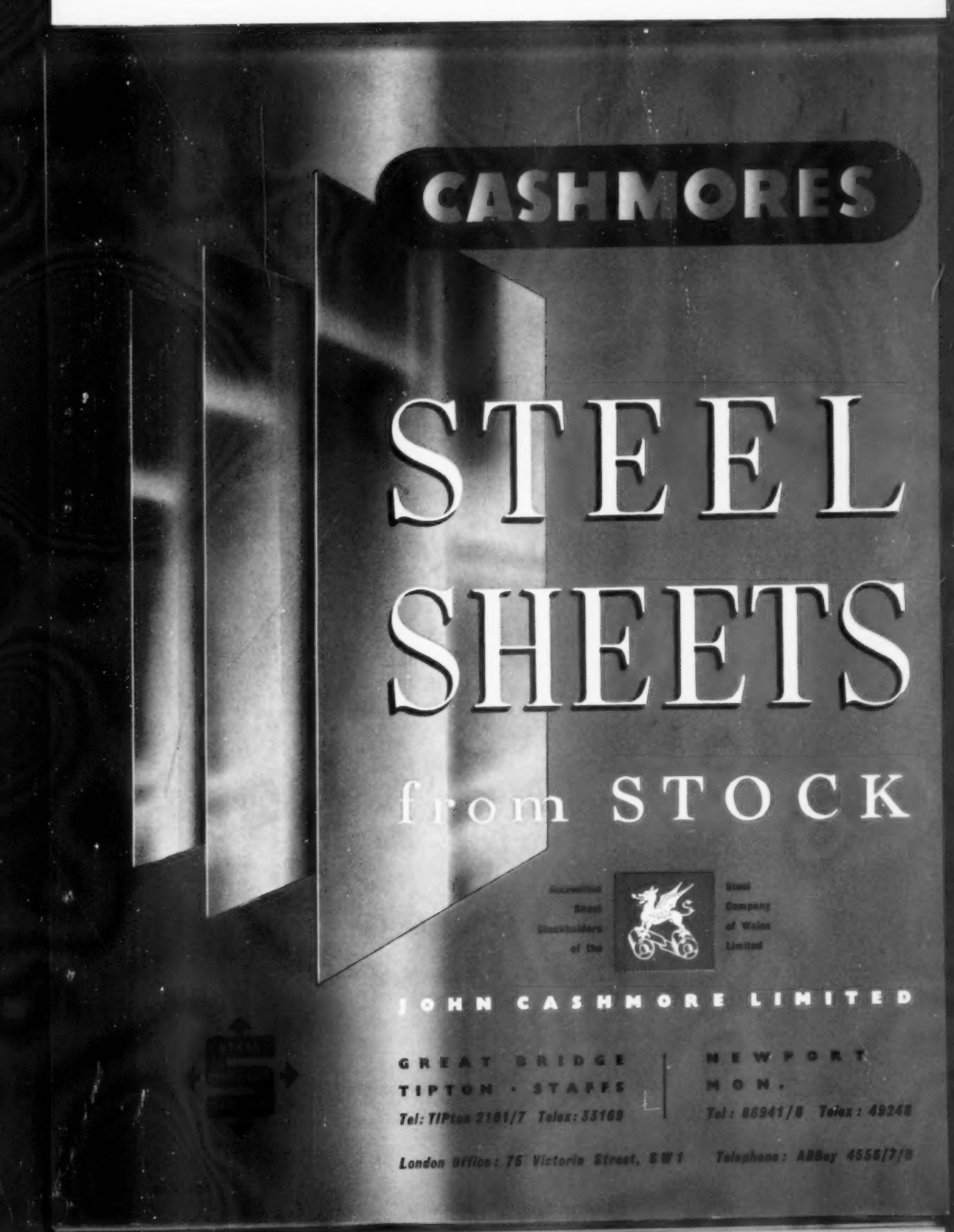
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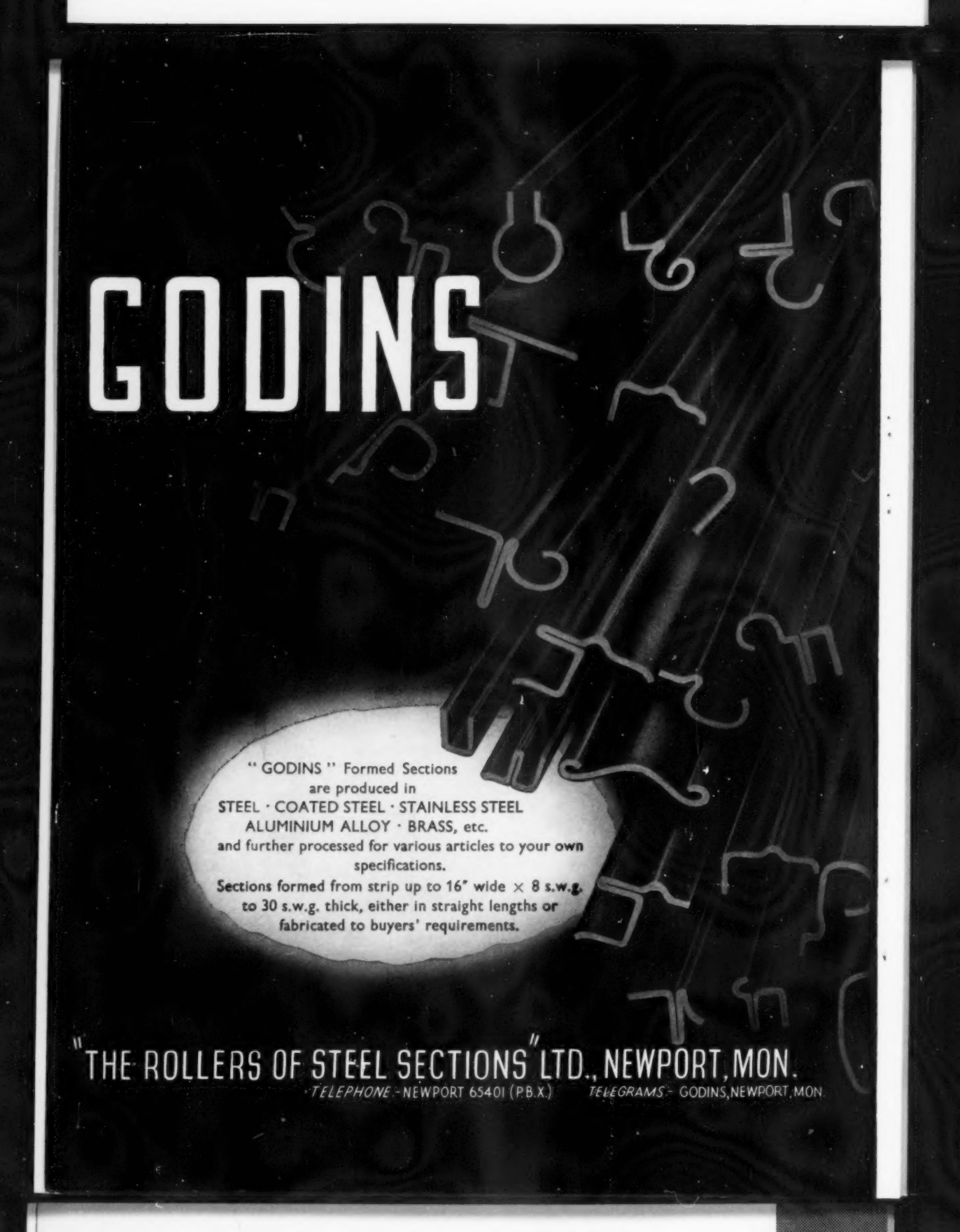
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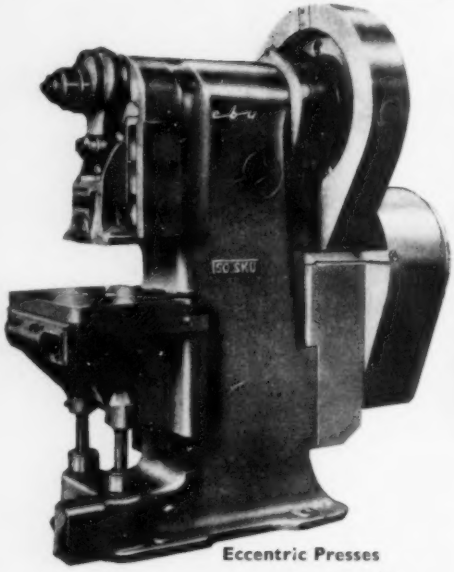

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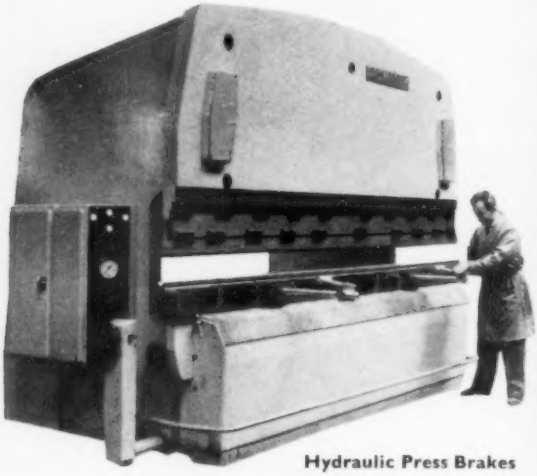

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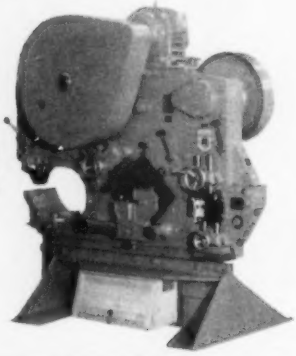

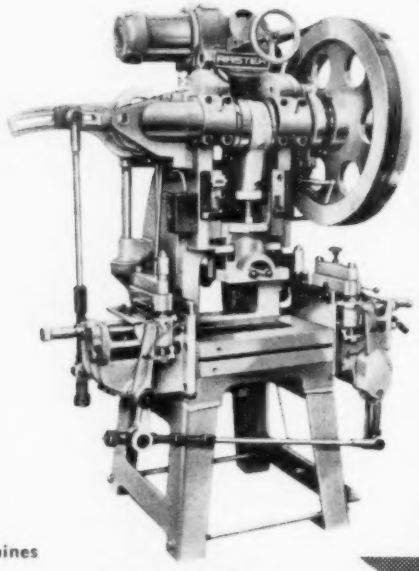

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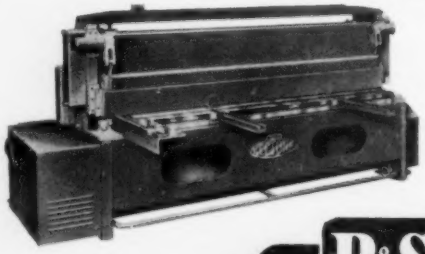

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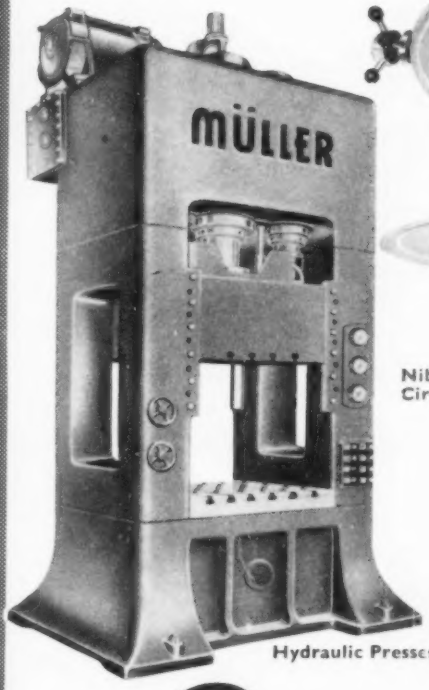

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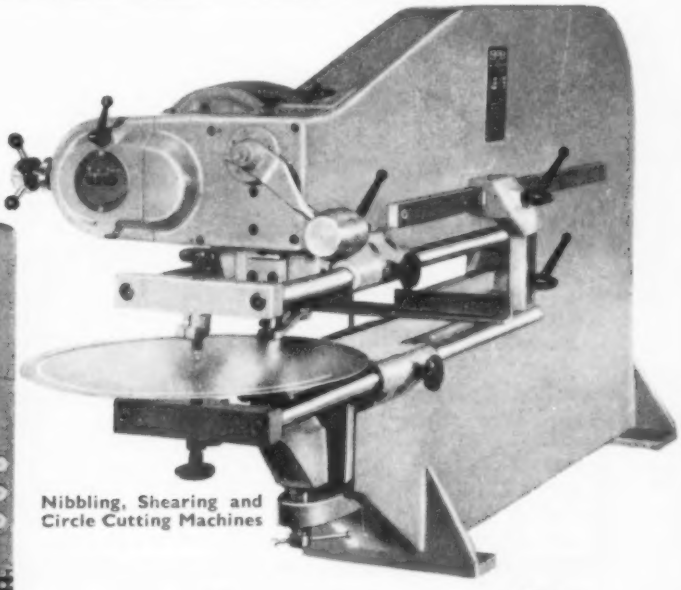

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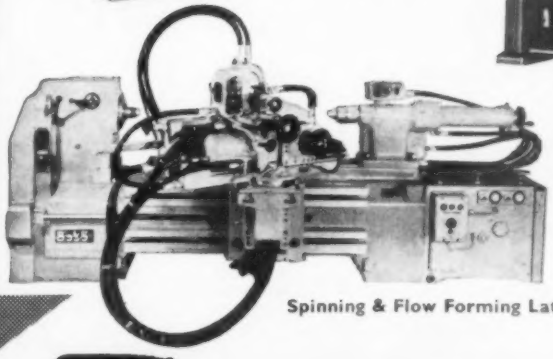

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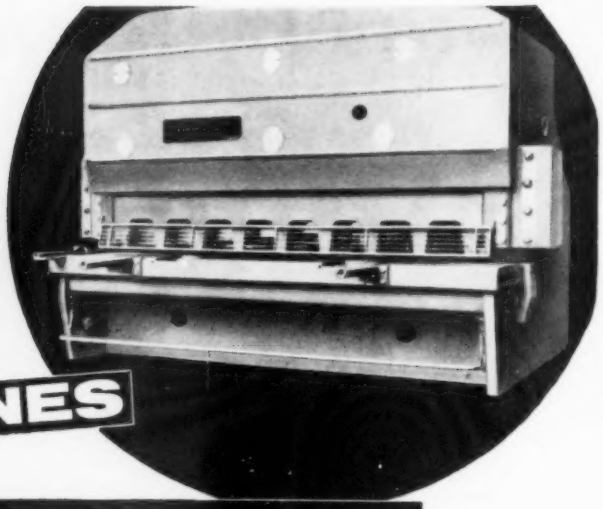

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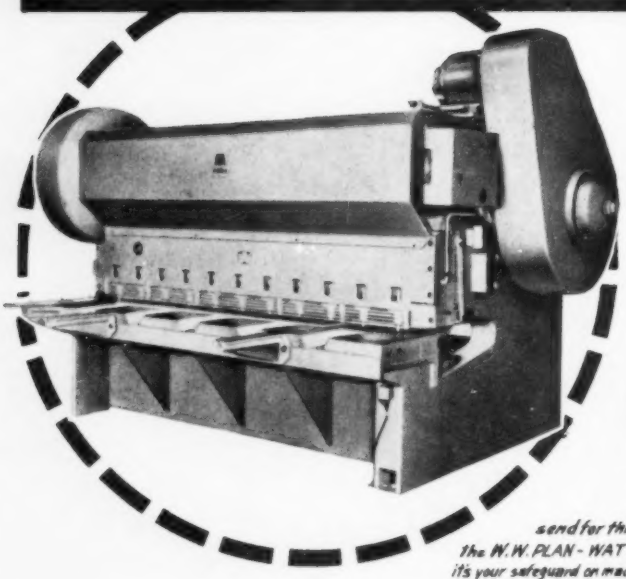
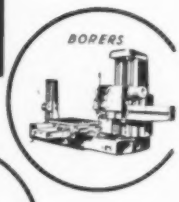
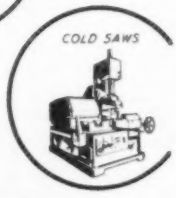
ScTP 16 x 3150	3/8" x 10'4"	2'3/4"	17 tons	32	







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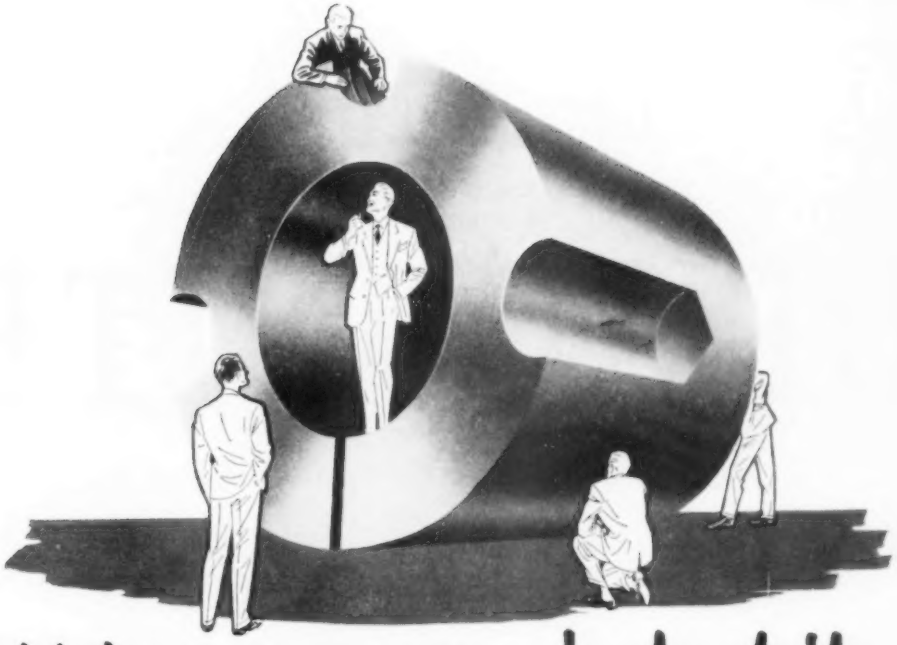

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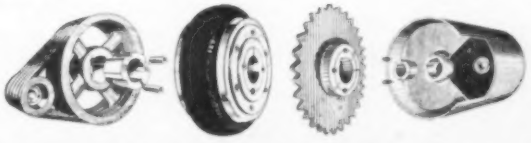

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electro-zinc coated steel
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For more detailed information about Dragonite and how it might fit in with your production plans, please write for a copy of the Dragonite Technical Handbook to:

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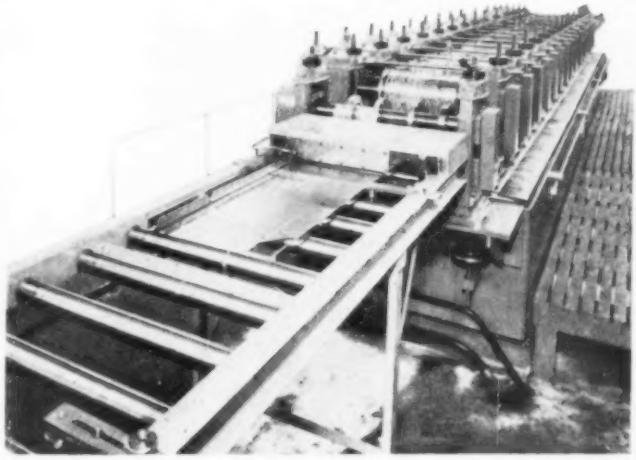
Sales Offices: United Kingdom - Abbey Works, Port Talbot, Glamorgan. Overseas - Margam House, 26 St. James's Square, London, S.W.1

COMEC

CREIL (Oise) FRANCE



5 French Companies are already using "COMEC" forming mills for the forming of refrigerator bodies.

An unattended machine will produce 5 lengths of 11' each in one minute without labour.

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Cold Roll Forming Machine for the producing of corrugated sheets and wide sections (max. width 5' 8").

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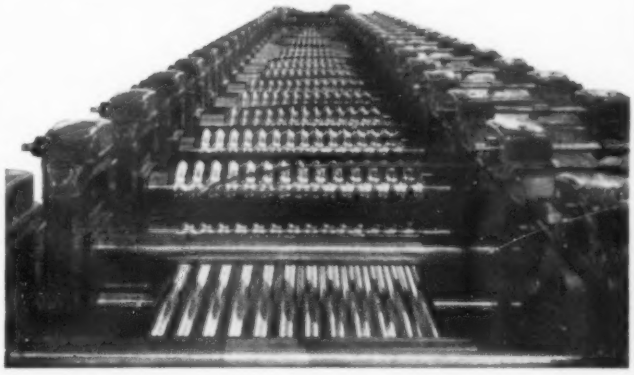

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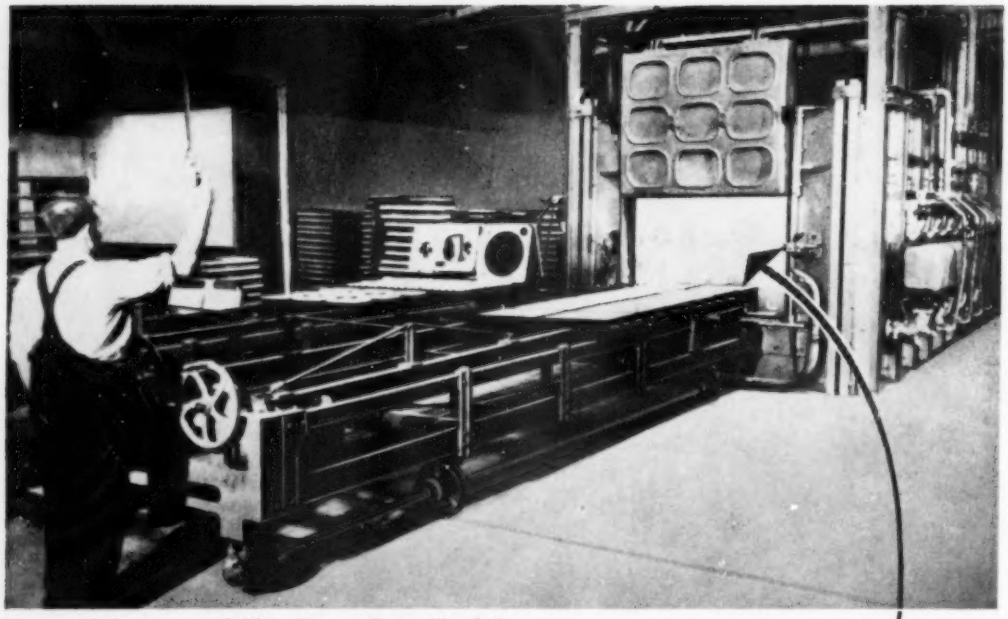

Photograph by courtesy of: Blake Vitreous Enamelling Ltd.

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Jetube firing has made its mark in the vitreous enamelling industry, bringing a consistency of finish and economy of operation never before obtainable.

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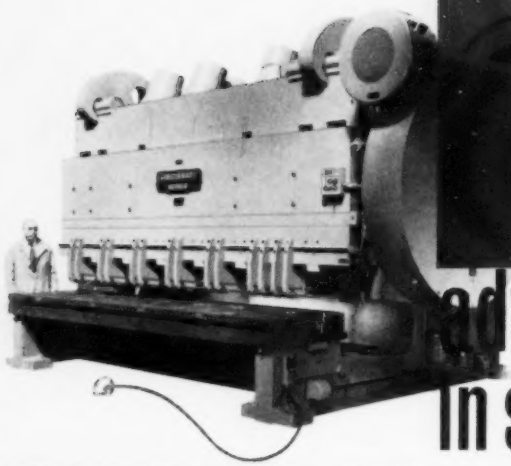
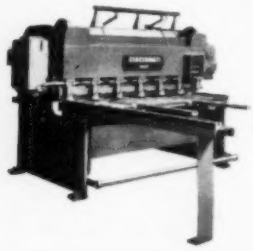


big advantages in shearing— no matter what size the machine



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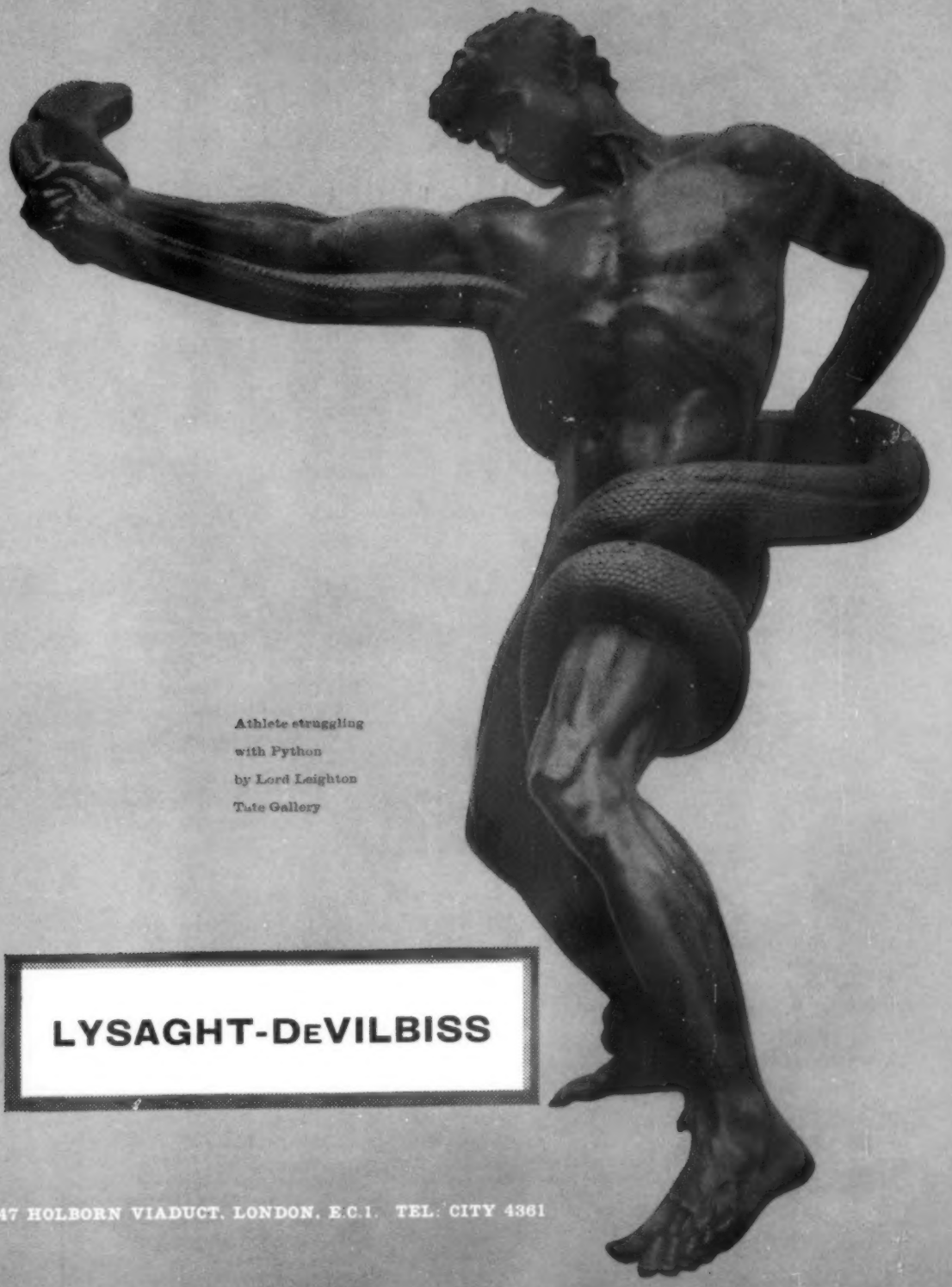

Athlete struggling
with Python
by Lord Leighton
Tate Gallery

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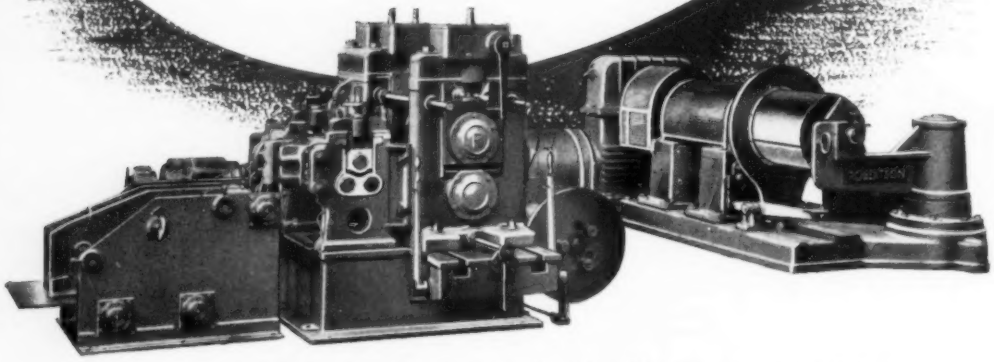
MACHINES



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metals at speeds up to 500 feet per minute.

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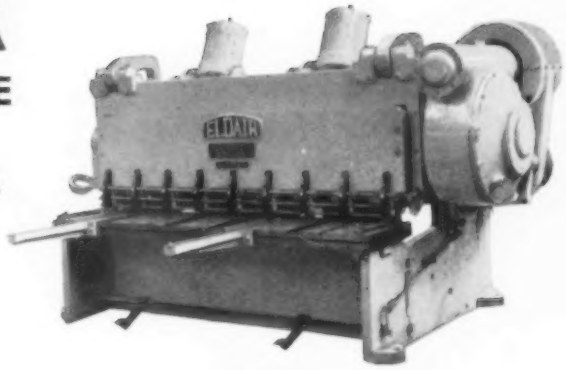
- Shear protected against overloading.



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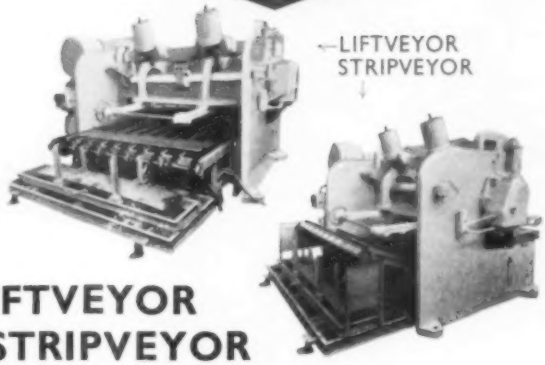

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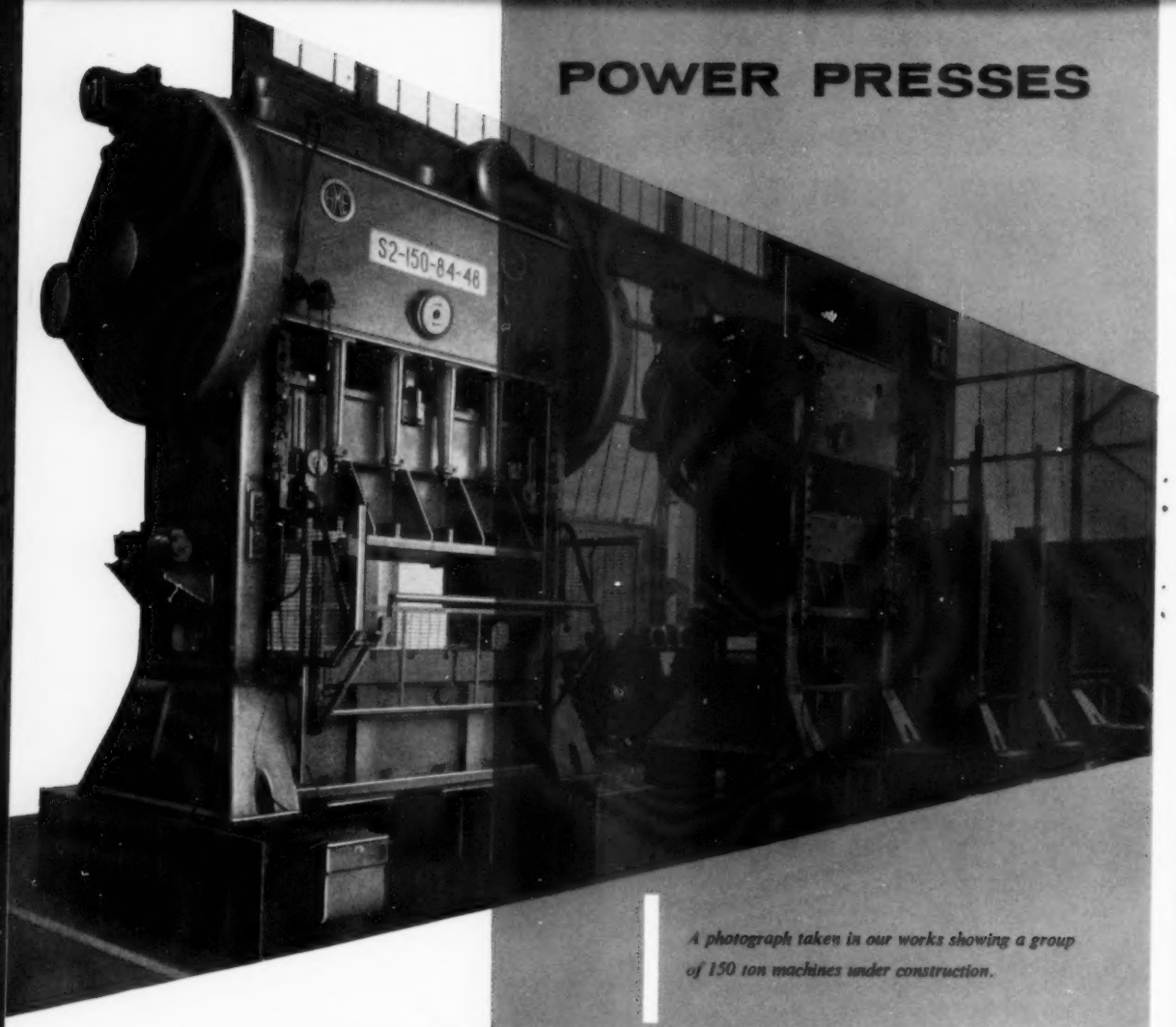

A photograph taken in our works showing a group of 150 ton machines under construction.

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The construction of presses in the larger range has become a production line affair. Send for details of the features of these machines or, should you prefer, we will be pleased to arrange for one of our specialist engineers to call.

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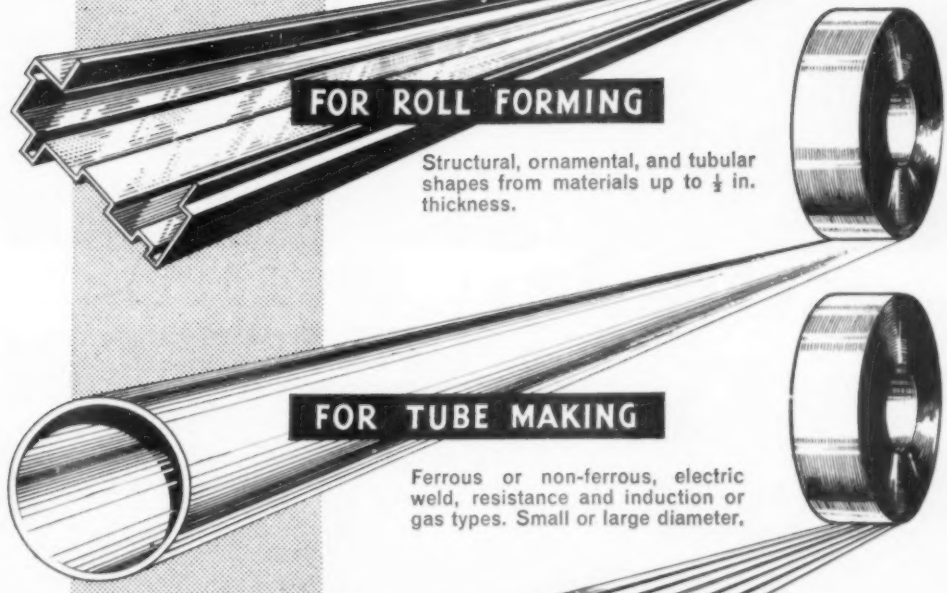

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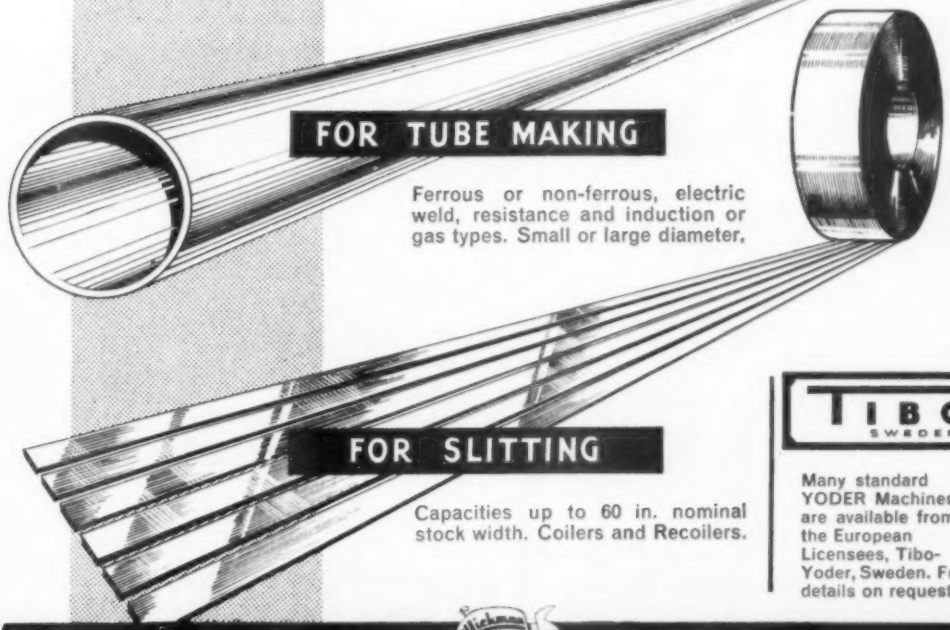

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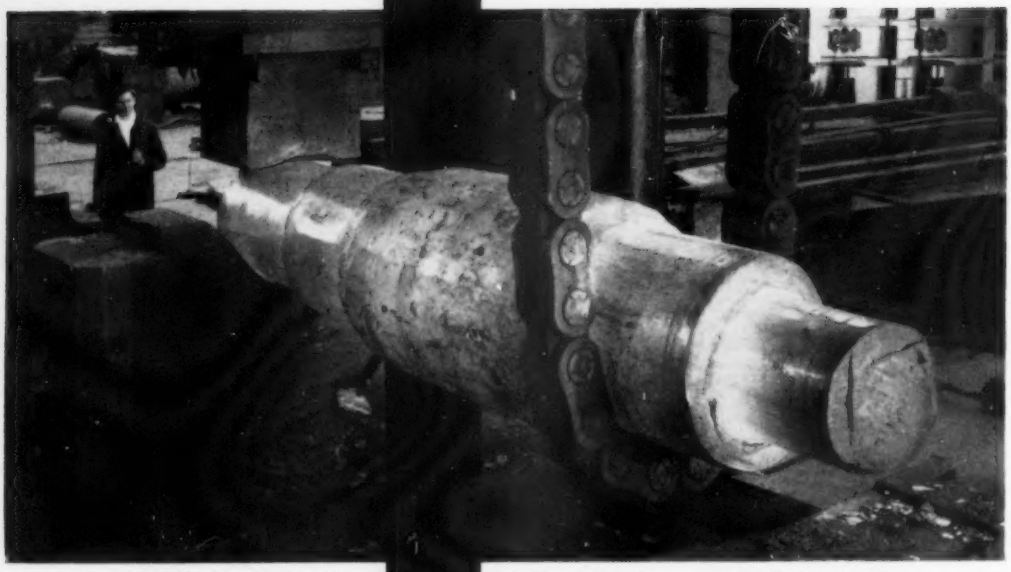

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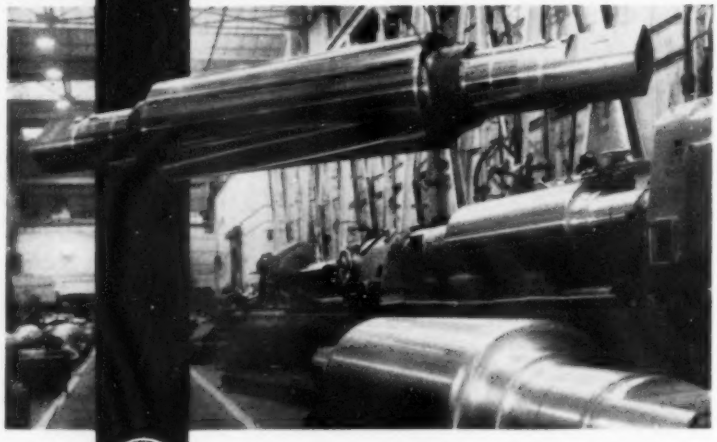

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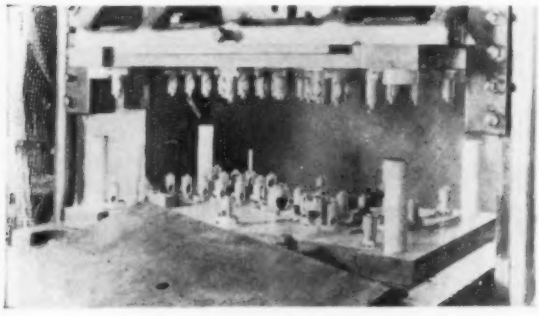

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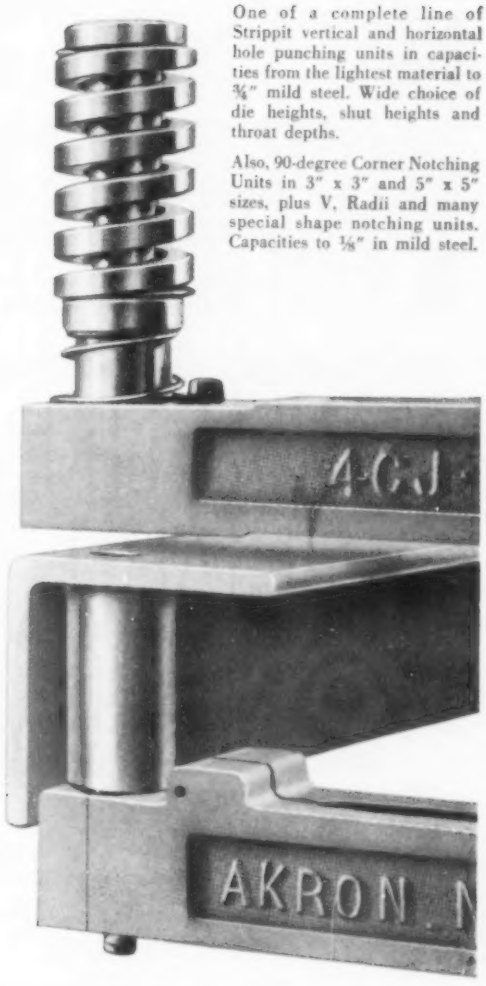

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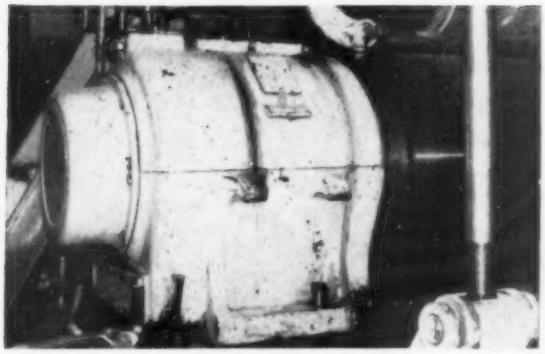

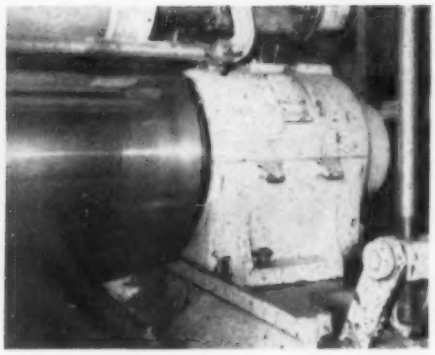

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This bearing ran successfully for many weeks, thus avoiding a major shut-down at a busy period.

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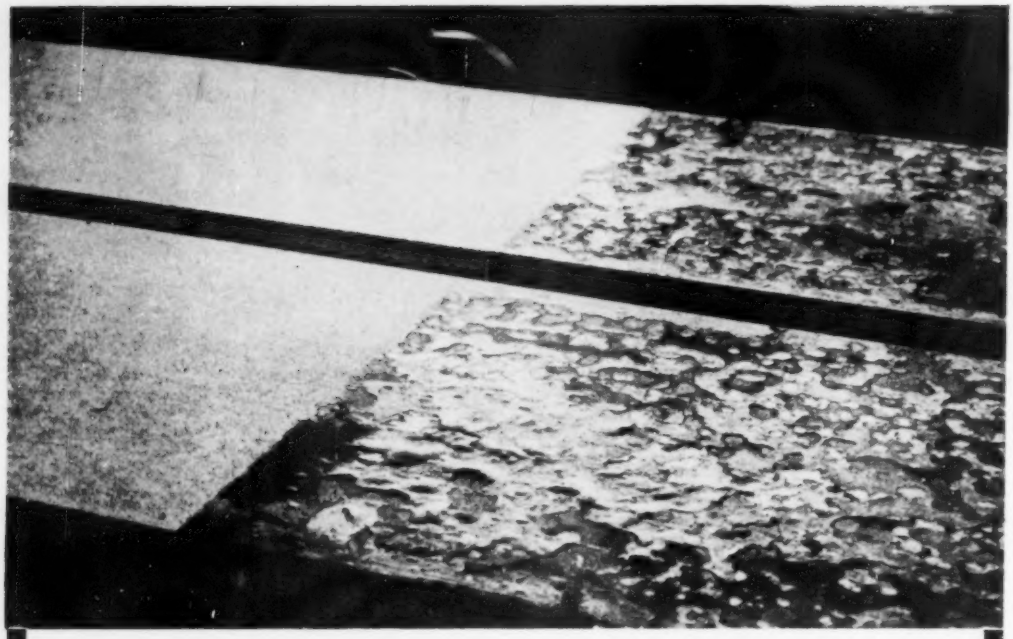

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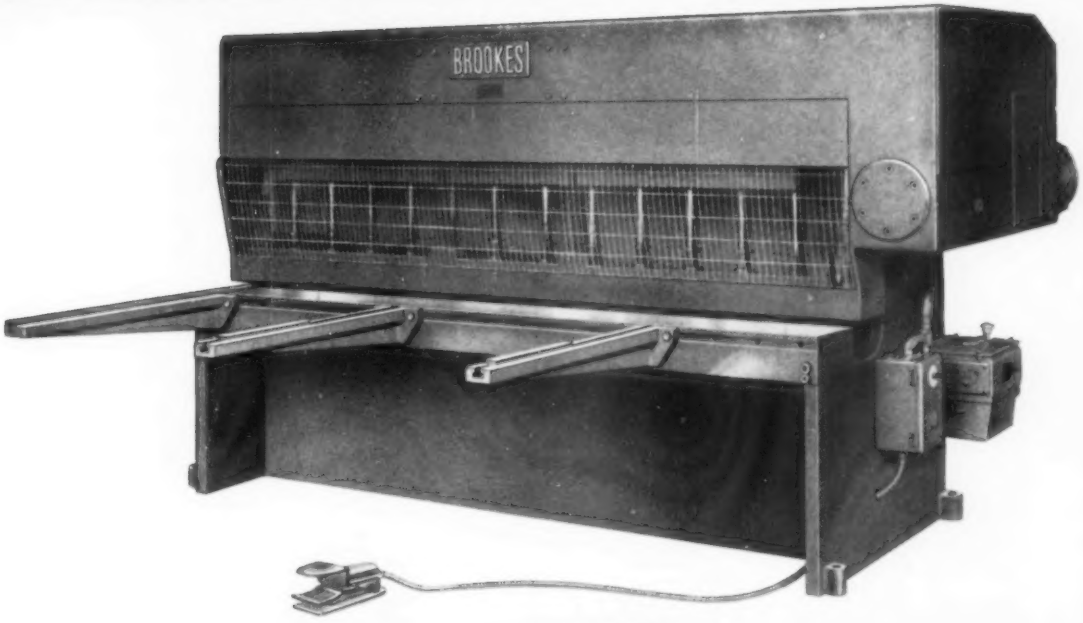

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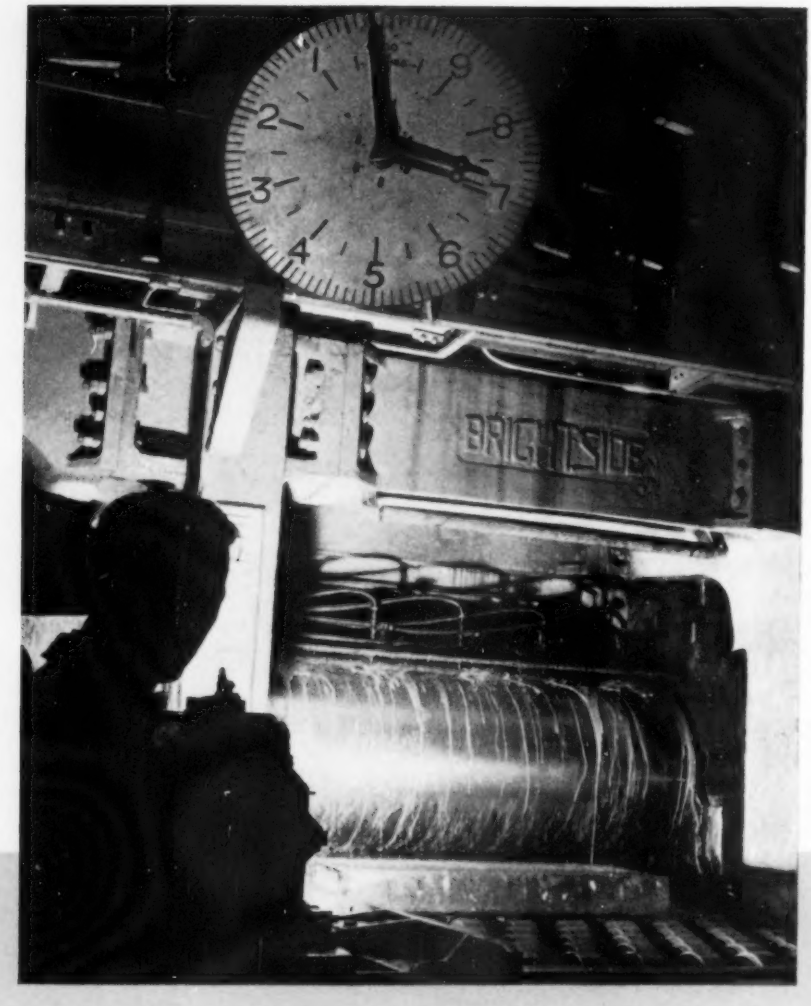

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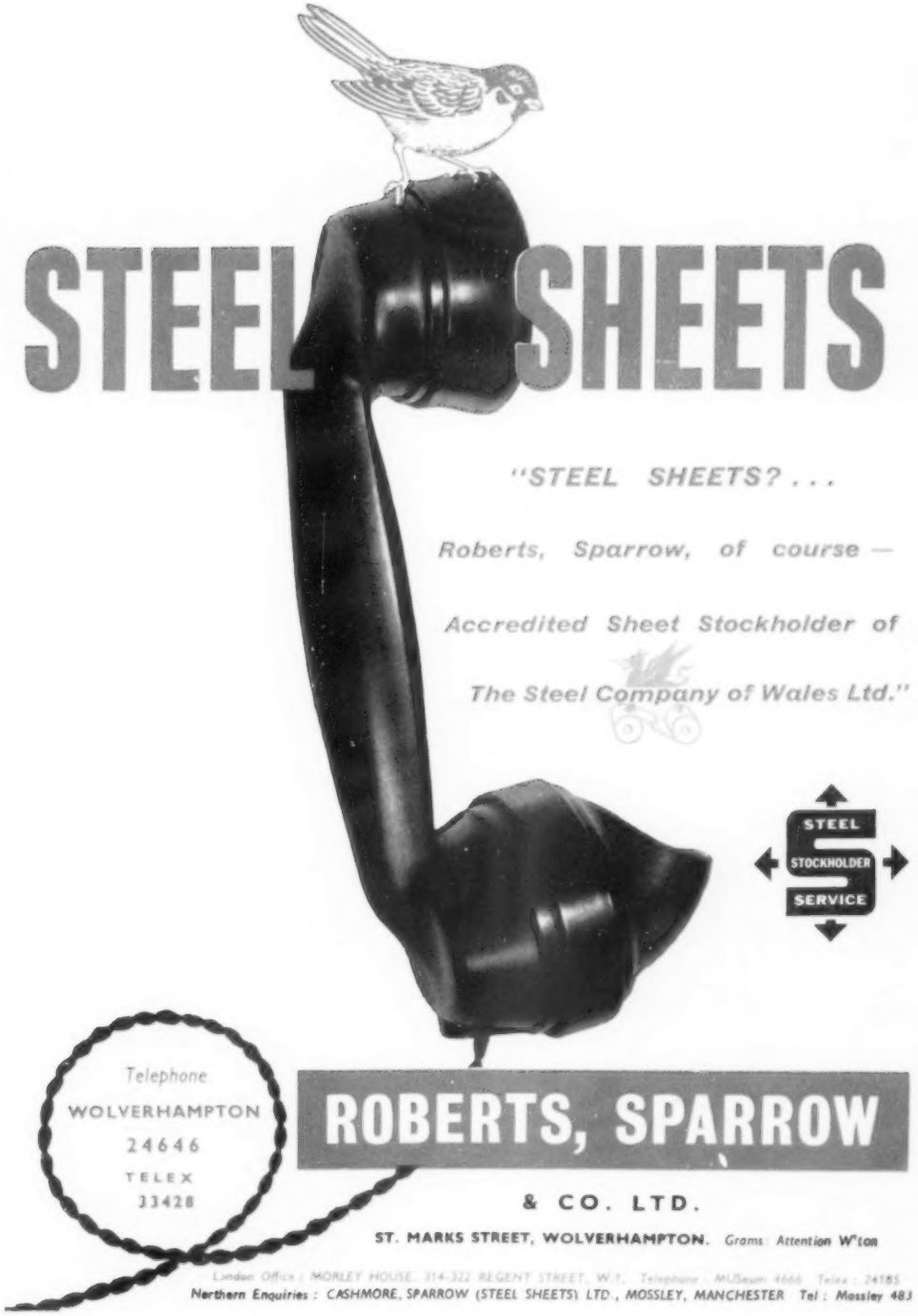

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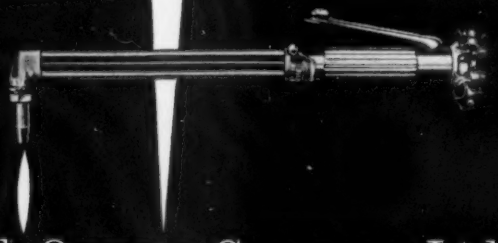

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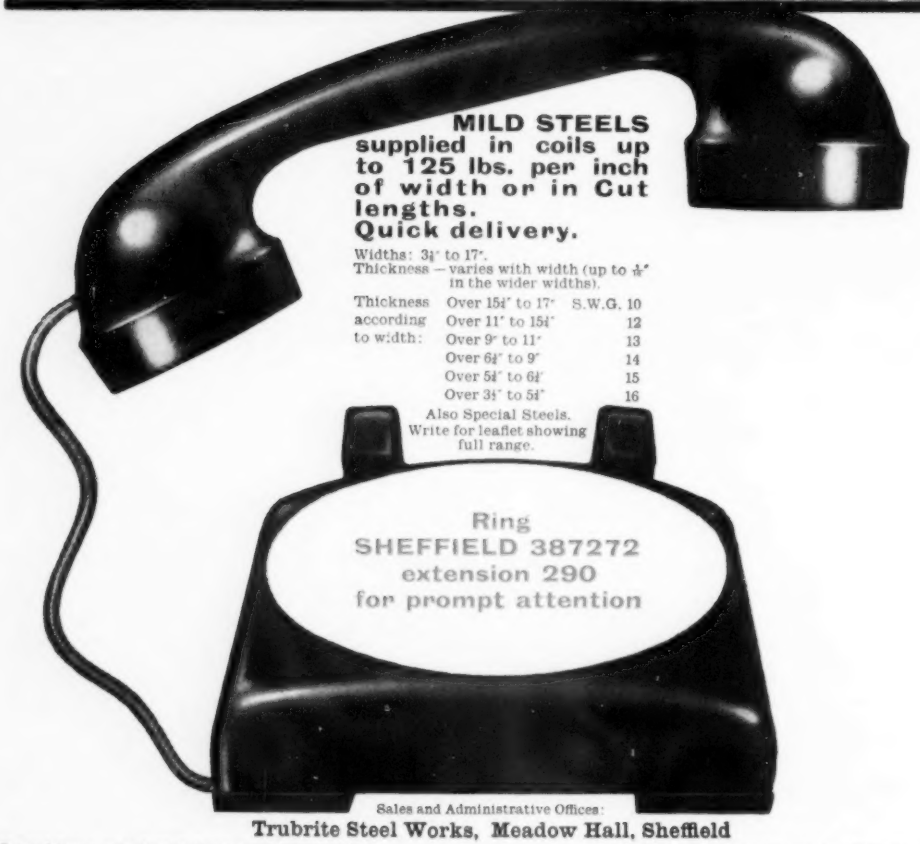

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STORDY

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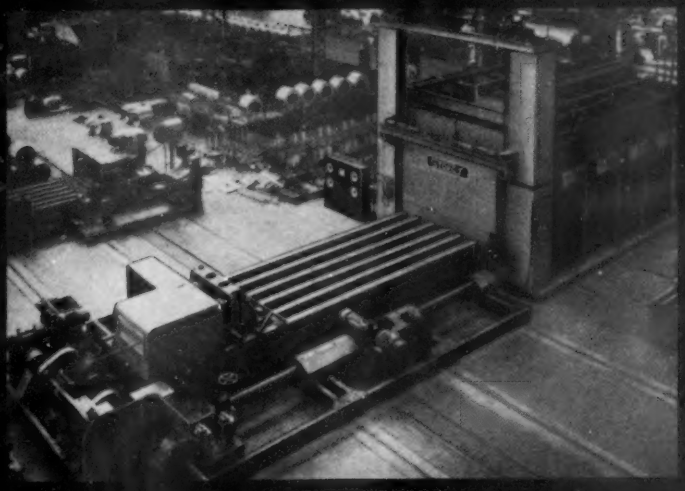

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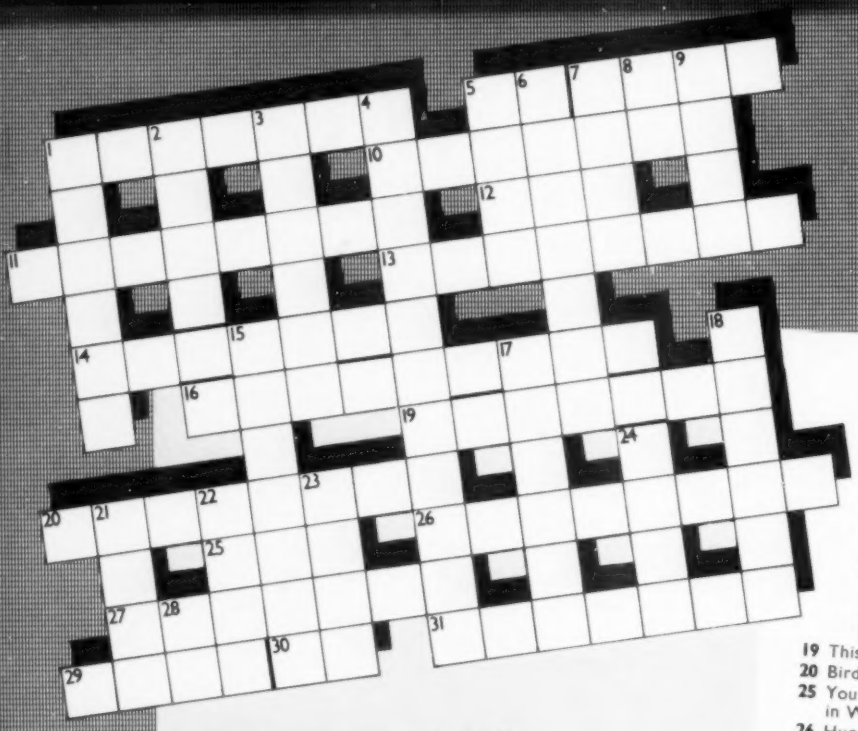

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CLUES ACROSS

1 Often involves restraint (7)
5 Copper card (2)
7 The wind in the reed makes it sound (4)
10 Bar the shouting? (3, 4)
11 Ten stung by an element (8)
12 A bit of stereo (3)
13 One may regard these as cut-outs or cut-ins (8)
14 They just splinter off (7)
16 Difficult and dissipated (4, 1, 4)
19 This shock absorber could be down (7)
20 Bird in a blazing circle (8)
25 You're sure of getting such drink in Wales (3)
26 Huge oars are needed to cope with this (5, 3)
27 A little woolly by the sound of it (3, 4)
29 A game side (4)
30 Found in 3 and 23 (2)
31 Enough to make Eddy lie (7)

CLUES DOWN

1 Part of the meal one can race round (6)
2 Covers the dark hours to a T (4)
3 Canine rodent operative (6)
4 Here we are again—the backbone of the job (5, 1, 5)
5 This sure is enjoyment (4)
6 Here's 20,000——men will know the reason why (7)
7 Small bakery (4)
8 Suggests insect half of 21 (2)
9 Morals are by word of mouth when the manuscript is lost (4)
15 I follow the vehicle before everyone turns up (7)
17 "—— a virtue if you have it not" said Hamlet (6)
18 Really in a legal document (6)
21 The earring depends on it (4)
22 Palindromic address to a lady (4)
23 It's tidy in Nuneaton (4)
24 Discard the outhouse (4)
28 Motoring organization shot up in wartime (2)

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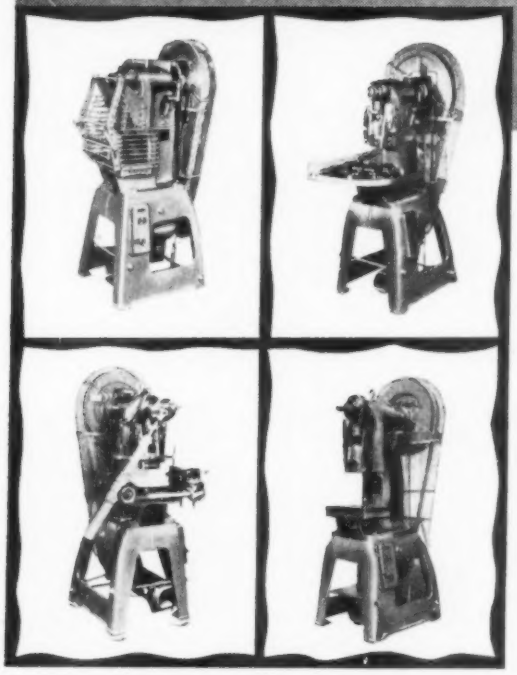

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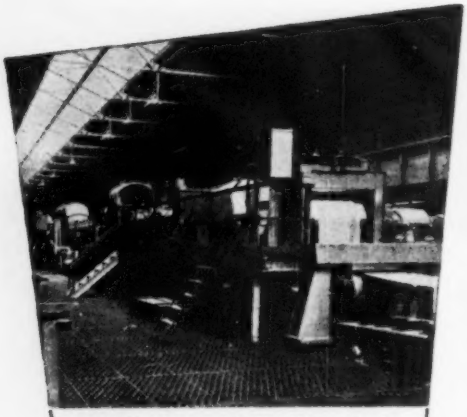
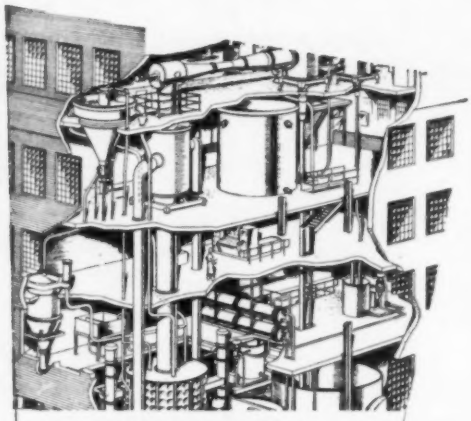


COMPLETE PICKLING AND ALLIED ACID TREATMENT PLANT: Continuous strip, plate, sheet, wire, forgings, castings, bar, rods, etc., ferrous and non-ferrous.



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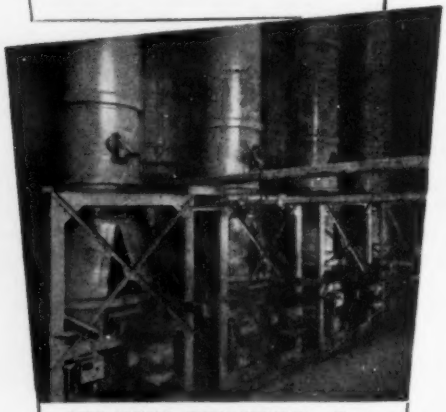

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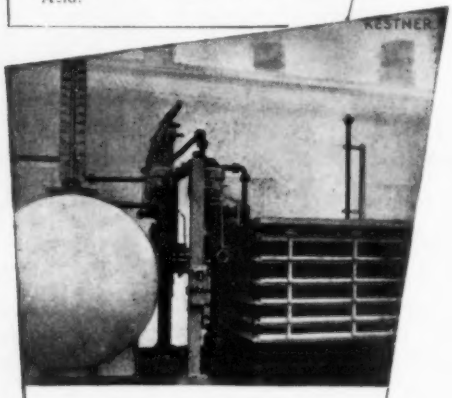

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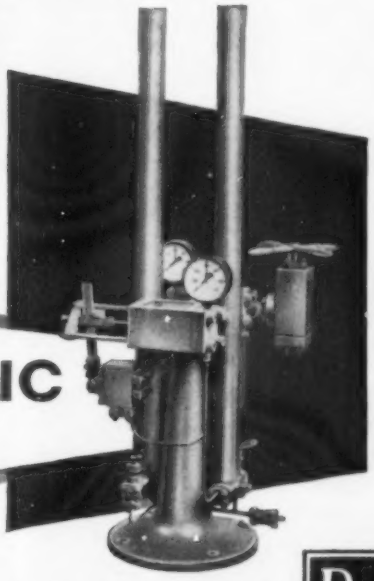

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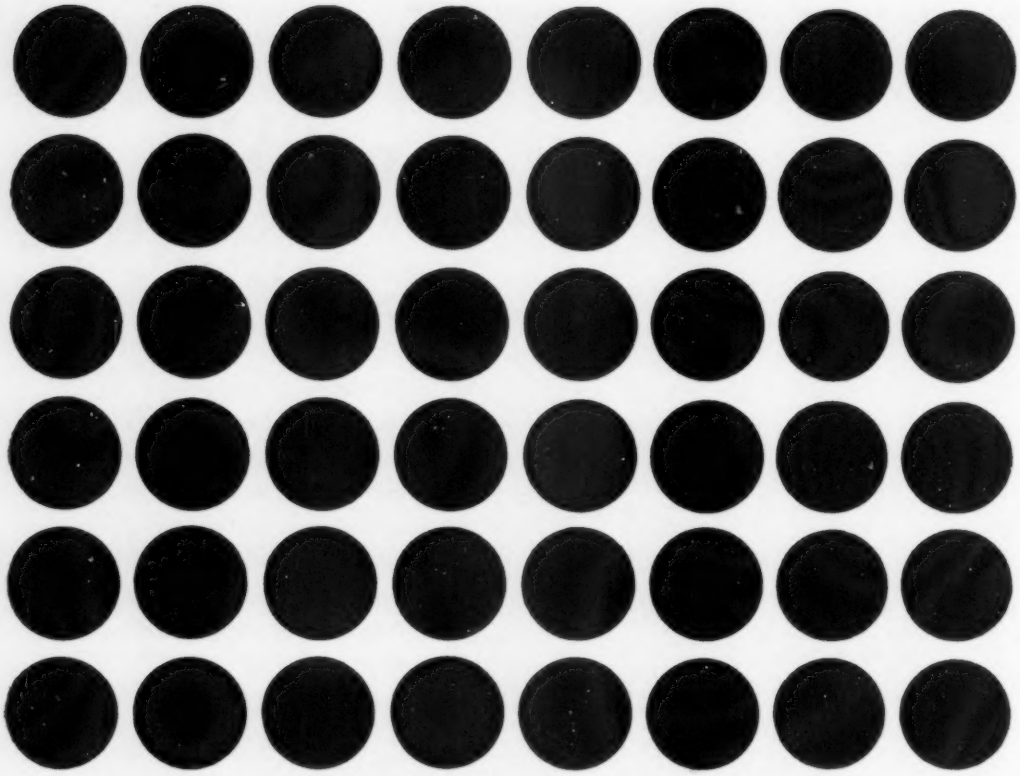

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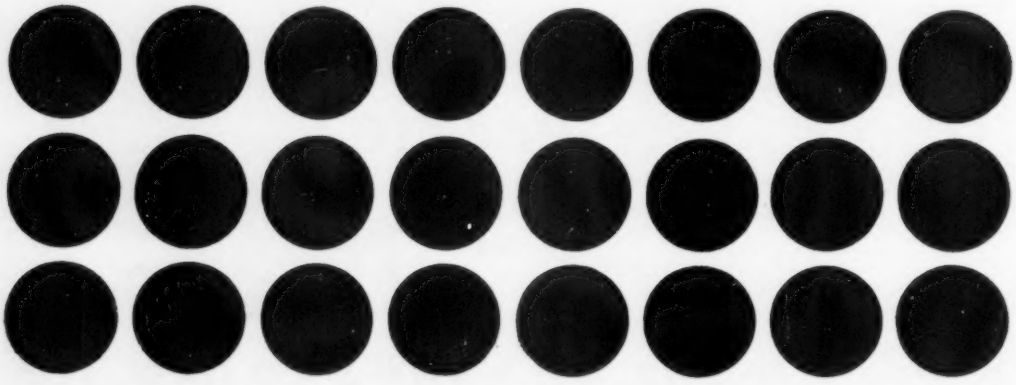

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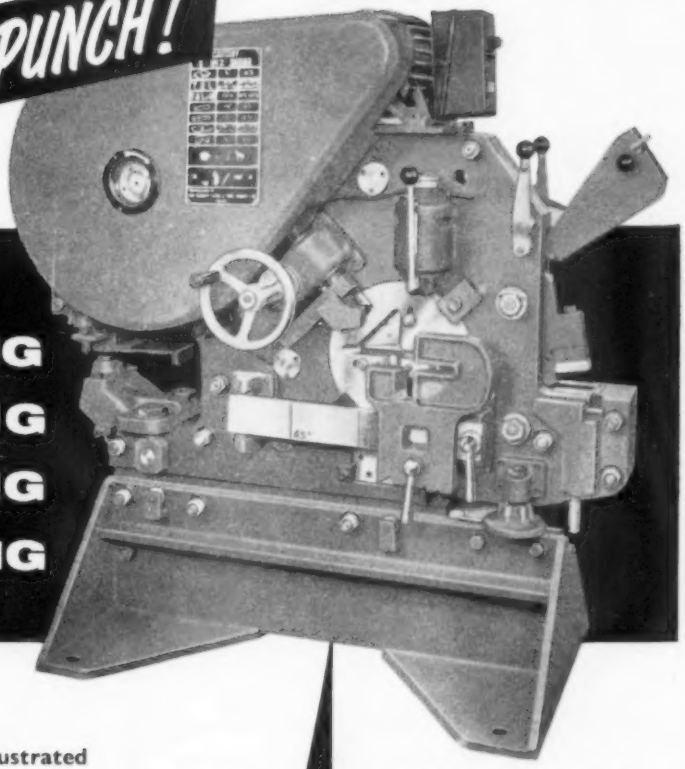

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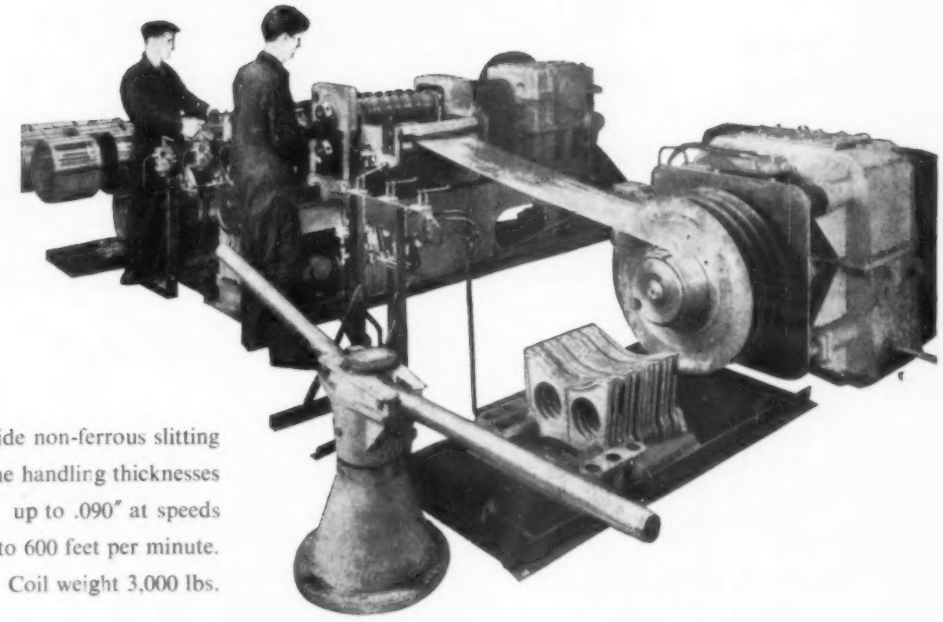

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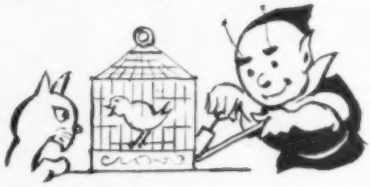

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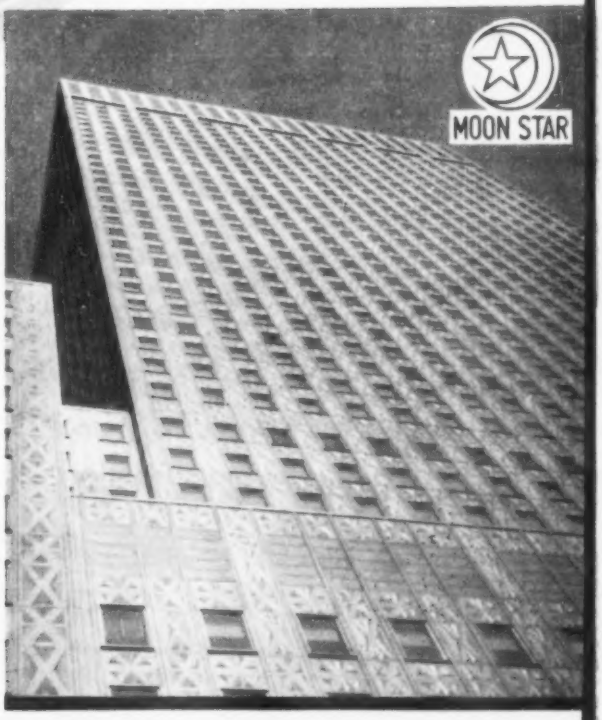

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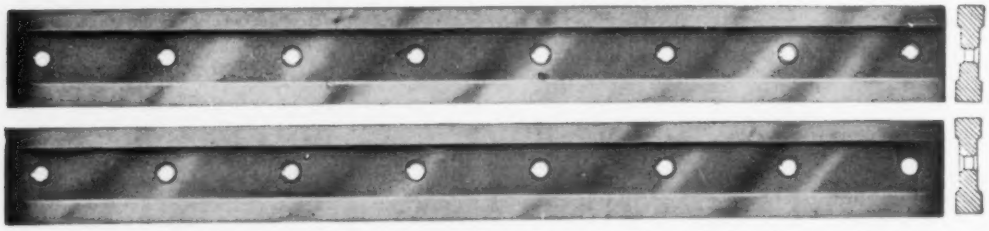

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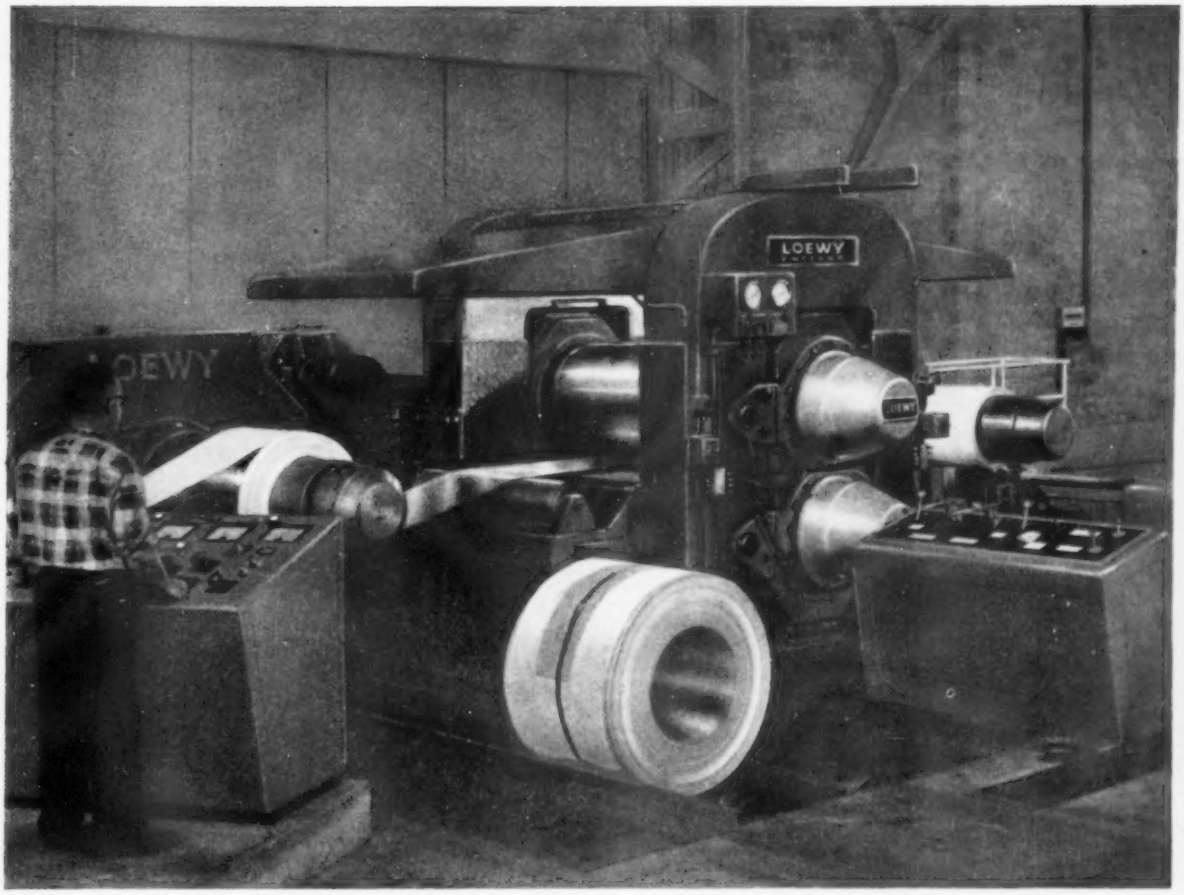

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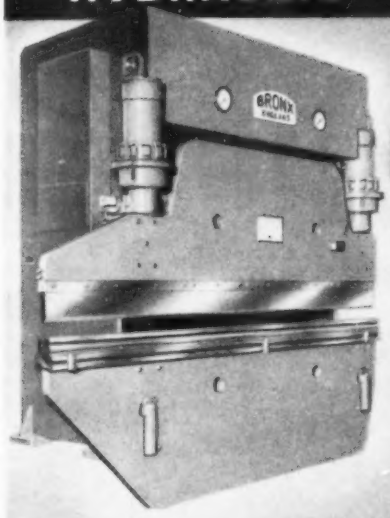

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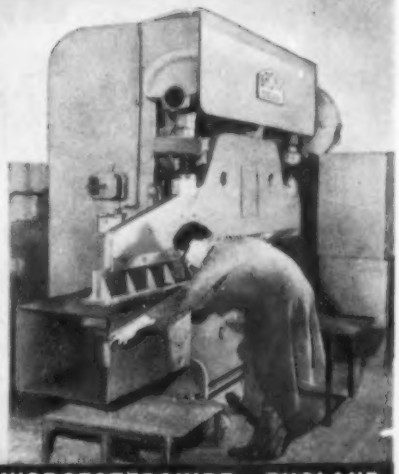

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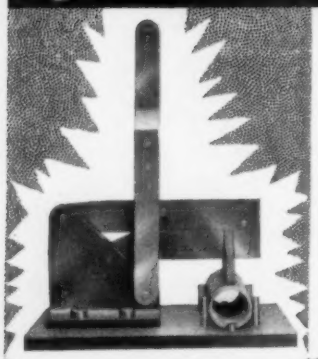
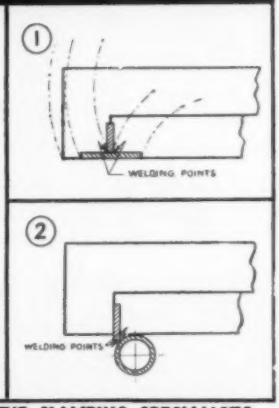
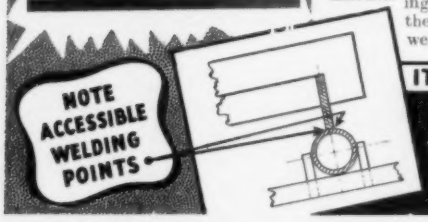


Speetog Welding Clamp

SOLVES AN OLD PROBLEM

The Speetog Welding Clamp, for the first time, makes it possible, not only to locate two components in relationship to each other, but also to clamp them both vertically and laterally in one movement. It is particularly suitable for assembly fixtures where ear plates, gusset plates and other similar components are to be welded to a main frame. As the illustrations here show, the components are securely located both laterally and vertically and at the same time during clamping, the welding points are retained in the most accessible position for the welding operator. *Patent No.* 660301





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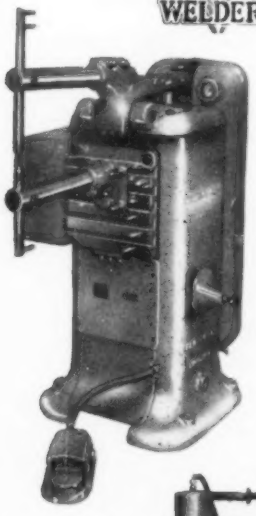

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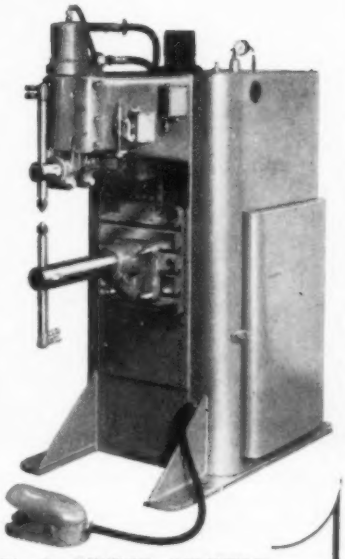
A 50 kVA Air Operated Spot Welding Machine with single spot and stitch welding operations. Four models are available from 25 to 100 kVA with choice of arm reach, time control and cylinder size.



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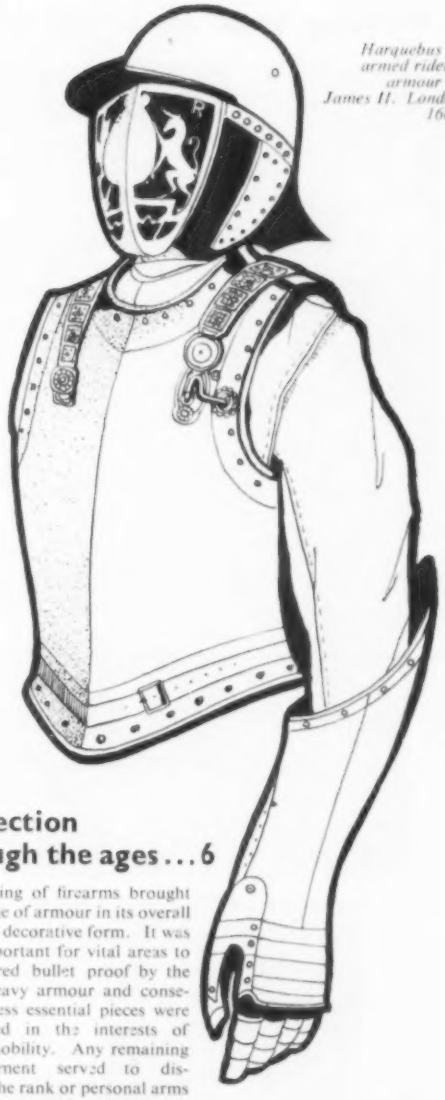
M-W. 117

Harquebus or armed rider's armour of James II. London 1686



Protection through the ages . . . 6

The coming of firearms brought the decline of armour in its overall and most decorative form. It was more important for vital areas to be rendered bullet proof by the use of heavy armour and consequently less essential pieces were abandoned in the interests of greater mobility. Any remaining embellishment served to distinguish the rank or personal arms of the wearer—and the heavily reinforced headpiece became the forerunner of the protective helmets of modern times.

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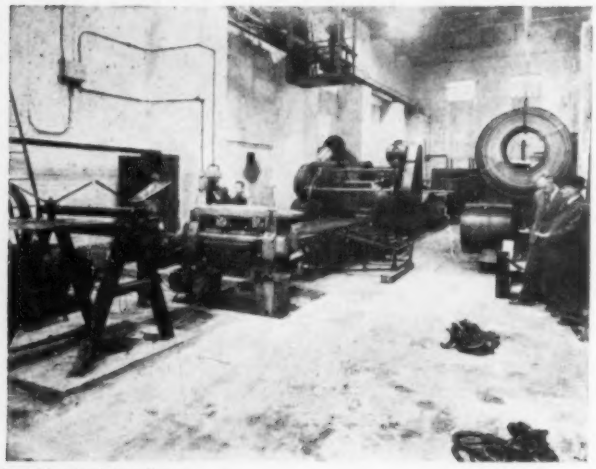

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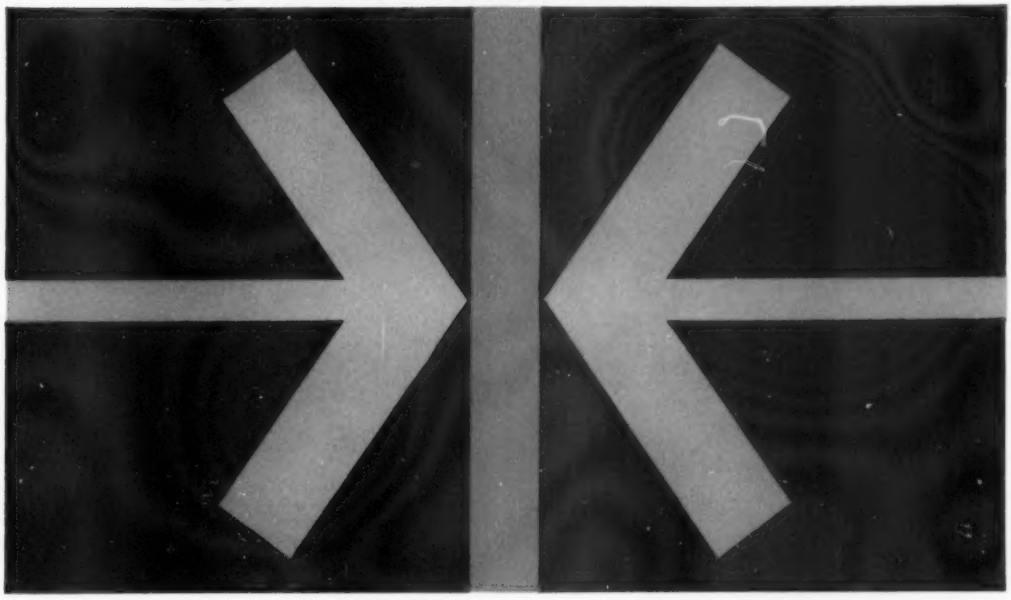

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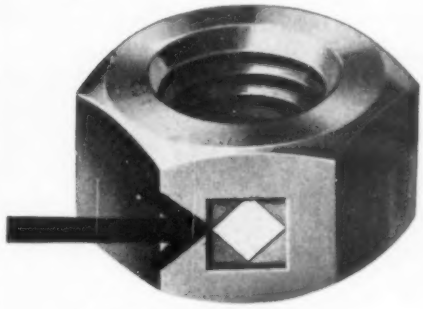

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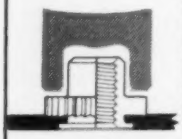

Punch or drill round hole in sheet metal to specific diameter. Insert smaller flange into hole. Apply impact force to exposed edge of serrated flange of Press-Nut.
Note that impact flows sheet metal into space between flanges, locking the Press-Nut securely in place. Teeth of the serrated flange broach themselves into the parent metal preventing rotation.

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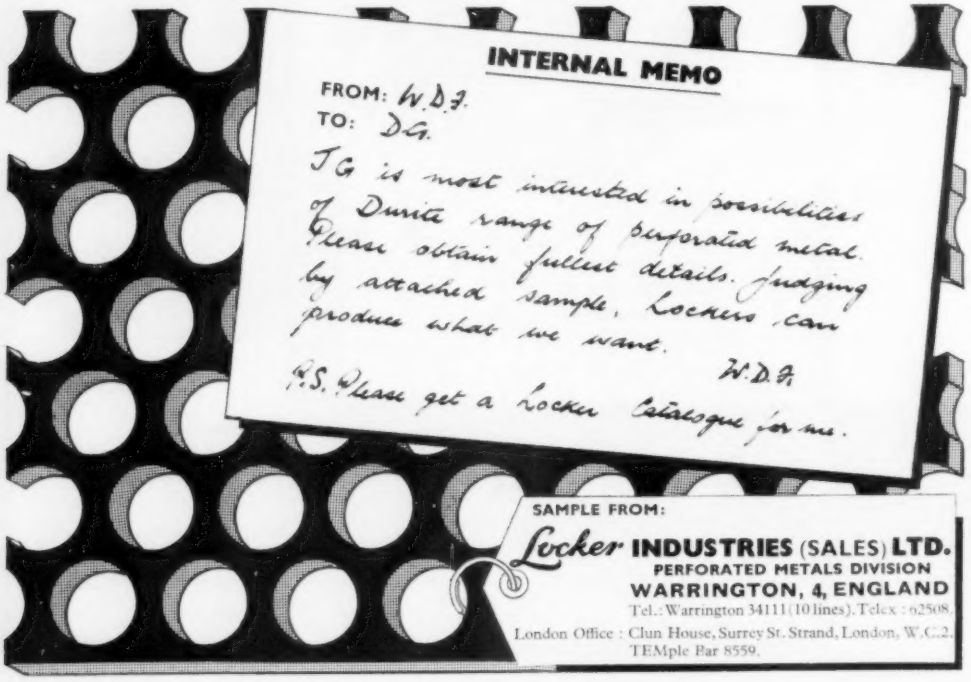
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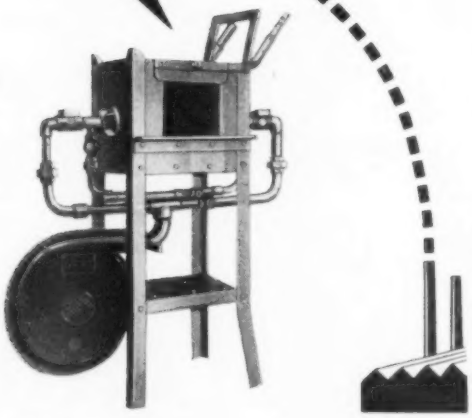

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Fixed stroke:	1¼", ¾" or ½"	1" or ½"	⅝" or ½"
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Open tool height:	8"	6"	4½"
Throat:	4½"	3½"	2½"
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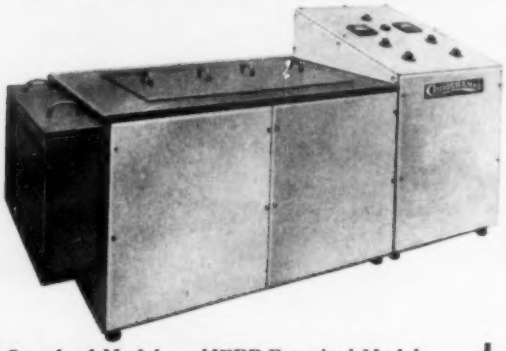
MEPP Electro-polishing MACHINE

for Brass, Nickel-Silver, Gilding Metal & Copper



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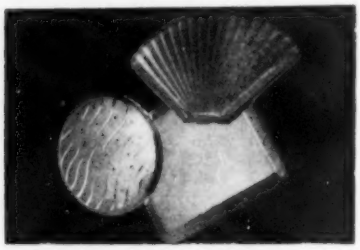

MEPP Standard Model
Capacity: 120 gallons
Overall dimensions:
Length: 8′4″
Width: 3′4″
Height: 3′0″
Height: 4′2″ rectifier section

MEPP Practical Model
Capacity: 35 gallons
Overall dimensions:
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Width: 2′7″
Height: 3′0″
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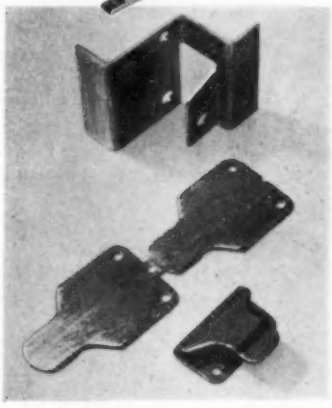

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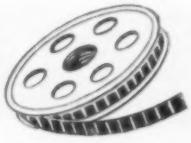

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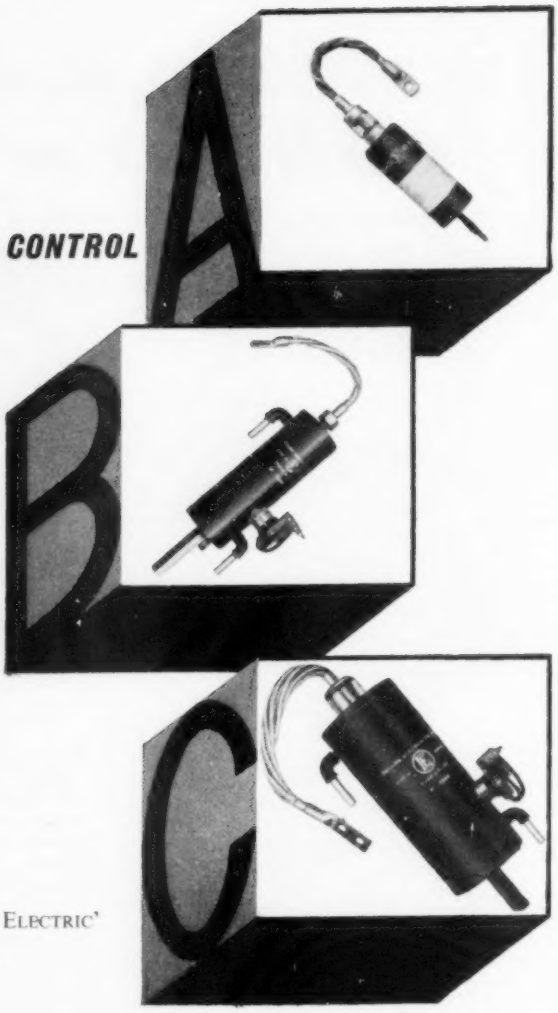

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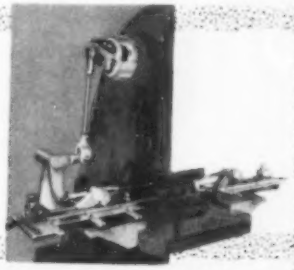

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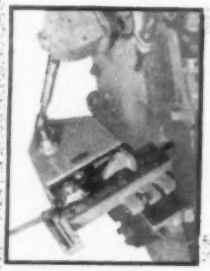

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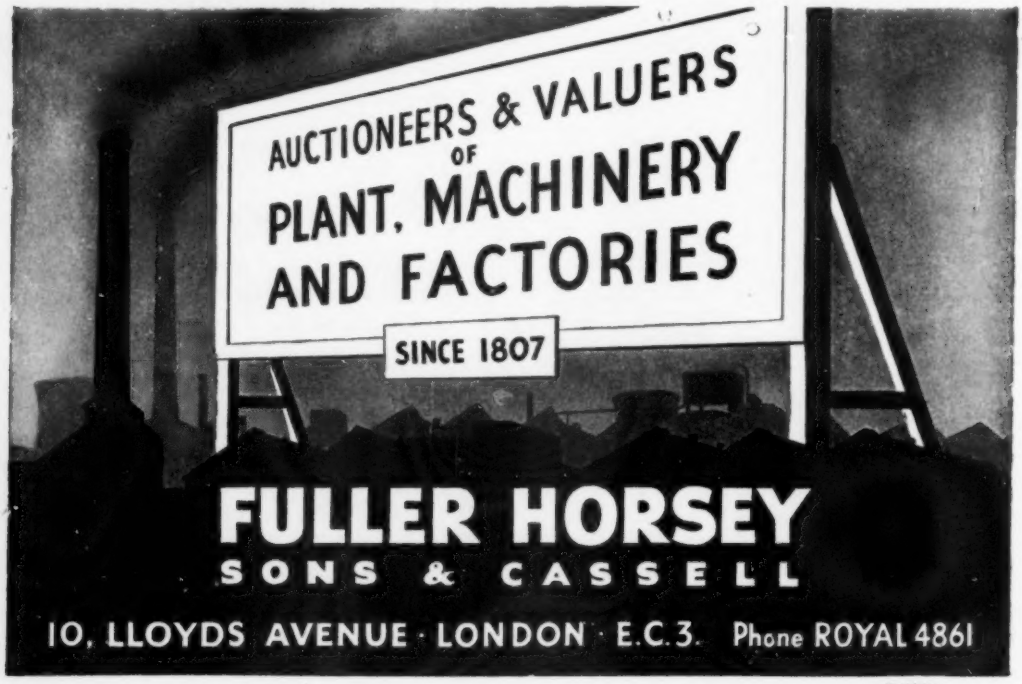

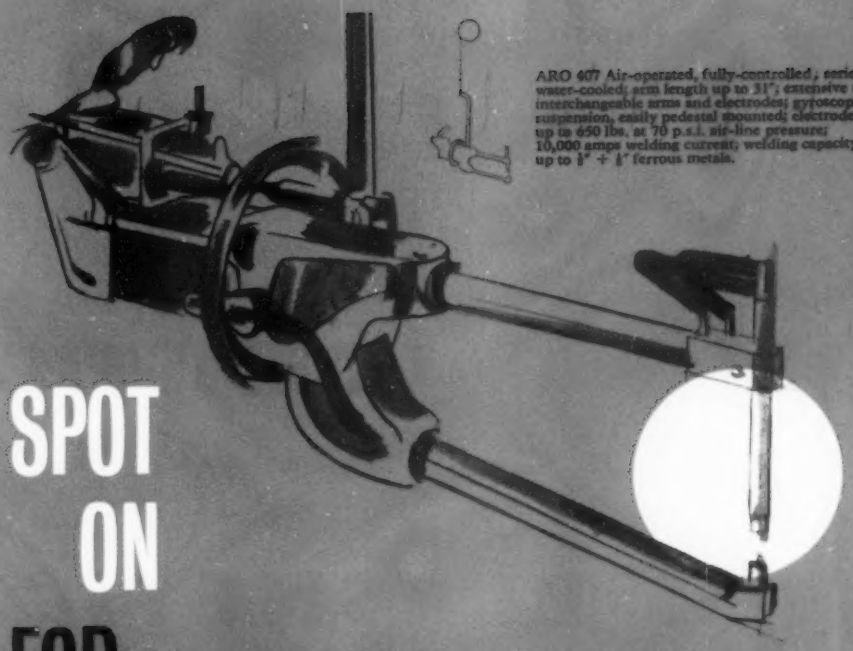

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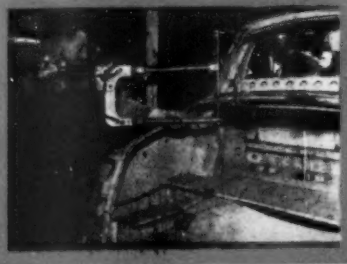
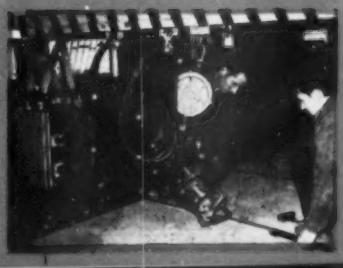
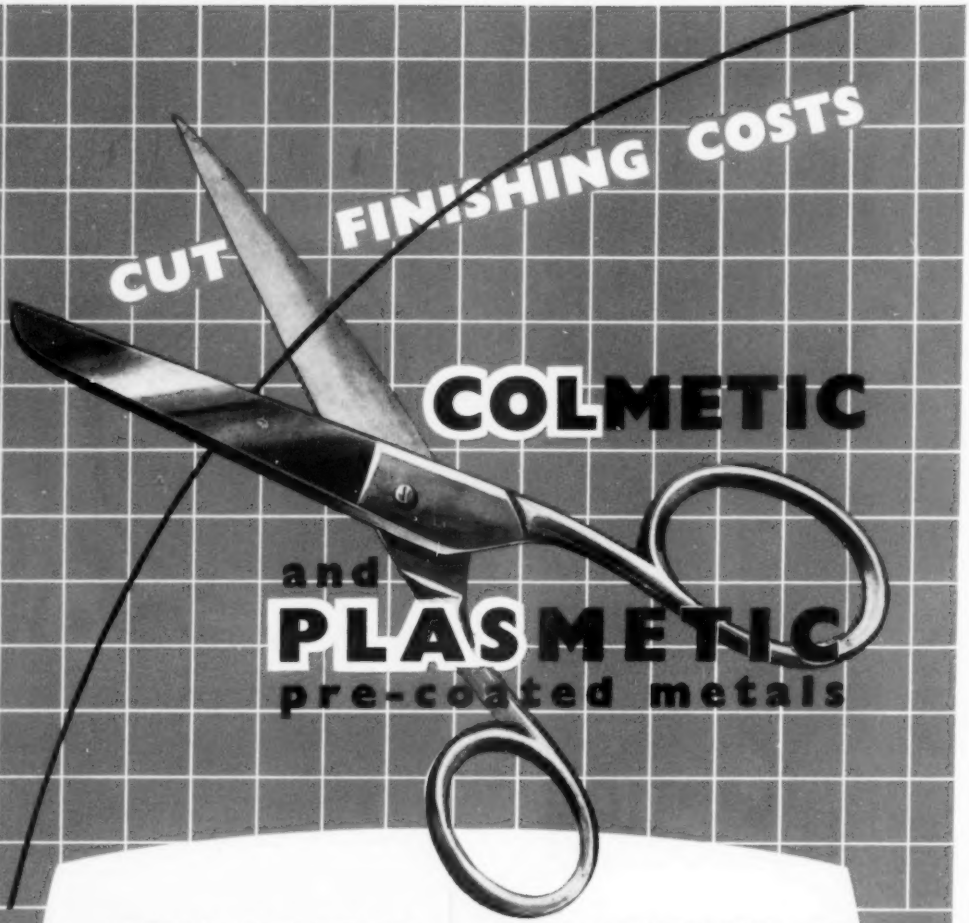
ARO 413 oildraulically operated gun welding a motor-car boot assembly.



ARO 413 oildraulically operated gun welding wall panels in pre-fabricated houses.



ARO 510 "Plate-Master" gun spot welding structural steel assemblies.



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South West England and Wales Agents: The Commercial Metal Co. Ltd., 13/20 Camomile Street, London, E.C.3. Telephone: Avenue 7901 (10 lines)

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GLASGOW
MACHINE TOOLS

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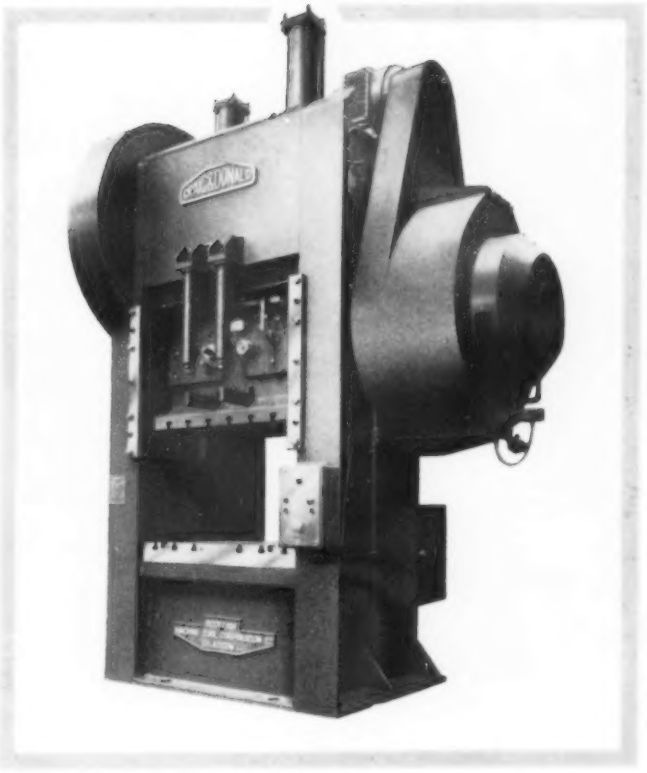

The press illustrated is typical of our small welded steel frame machines. It is rated at 250 tons, with bolster size 30 in. front to back and 45 in. right to left. The stroke is 8 in. and slide adjustment 6 in.

From the photograph, the lines of the well-proportioned frame can be seen. It is an all-welded fully checked structure of ample rigidity and strength, with provision for the accommodation of various items of ancillary equipment safely out of harm's way. We can easily arrange for any holes which may be required for strip feeding, the removal of work or scrap, and so on.

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The drive of the press is by a pneumatically operated friction clutch and brake, provided with simple adjustment. Various styles of push buttons and pedals are available with provision for interlocking with guards if desirable. For short and medium stroke presses we use our solid eccentric main shaft, which offers great advantages in the avoidance of torsional strain, the use of narrow bearings (still retaining ample area) and ease of withdrawal without dismantling the bearings, when maintenance is necessary.

We feel that our presses offer great advantages of careful design on well-proven principles, carried out with the best materials and workmanship and we should be pleased to have your enquiries so that detailed proposals may be submitted. We have fully illustrated booklets of the different types of presses and should be glad to send copies at your request.

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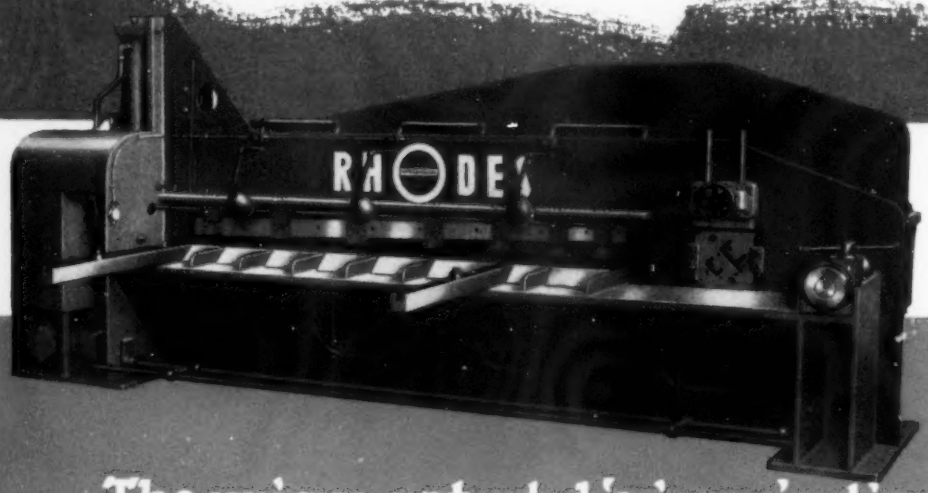
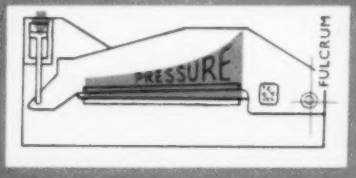
RHODES

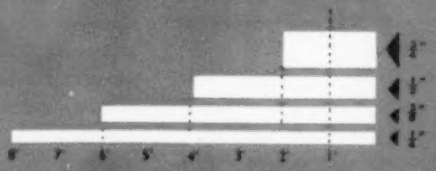
HYDRAVERSAL SHEARS ..



The unique patented 'scissors' action !



The rake of the top blade is inclined upwards *towards* the fulcrum of the 'scissors', giving progressively increasing pressure.



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cuts any of these ...

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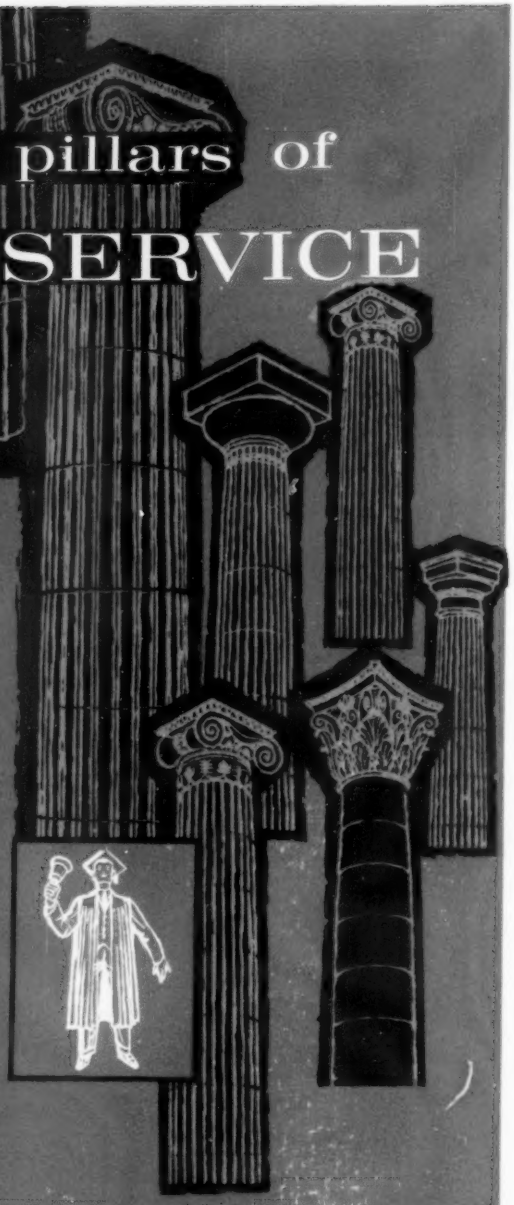
RHS 3

The seven pillars of TOTAL SERVICE



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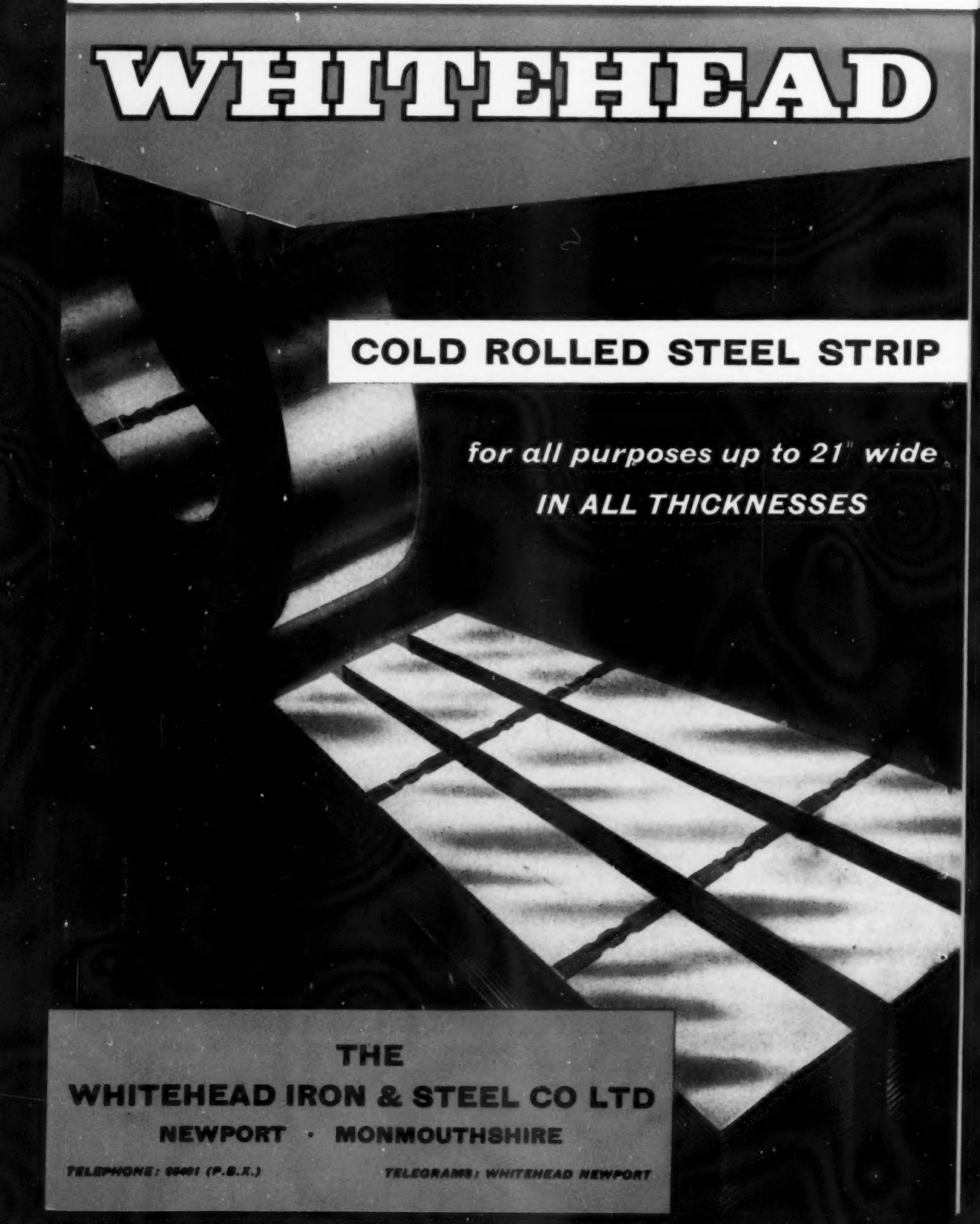

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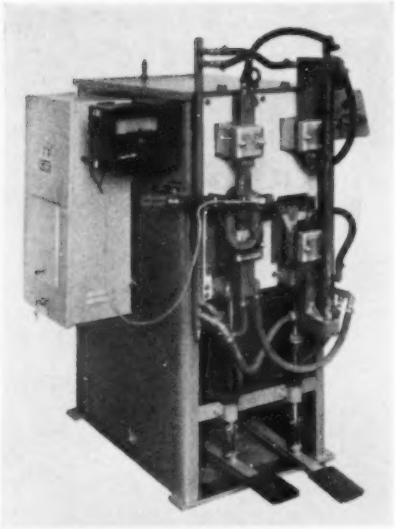
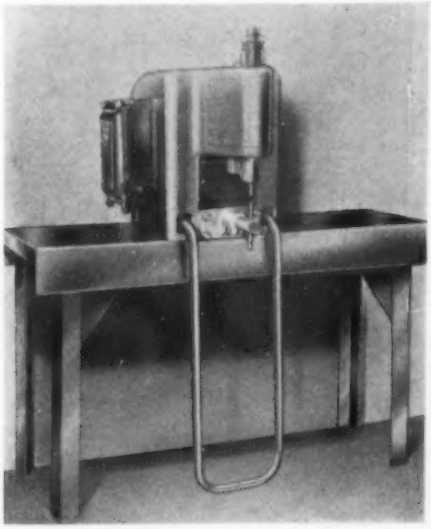


50 KVA Combined chain link annealing machine and bar heater.



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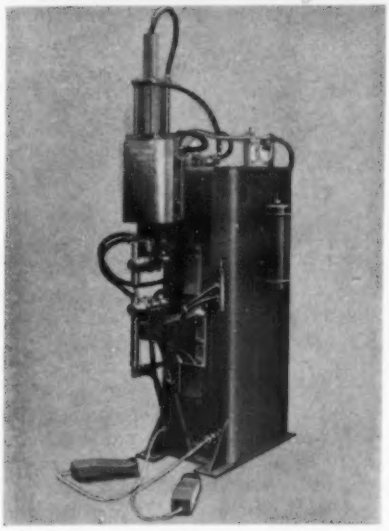

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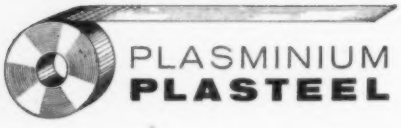

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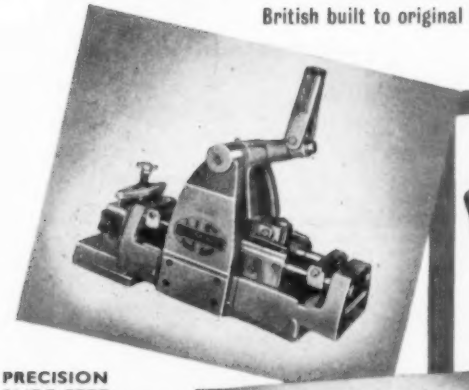

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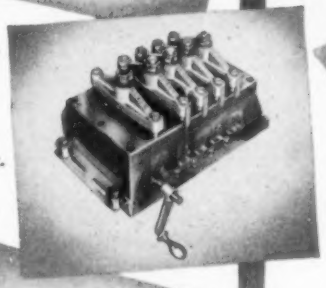

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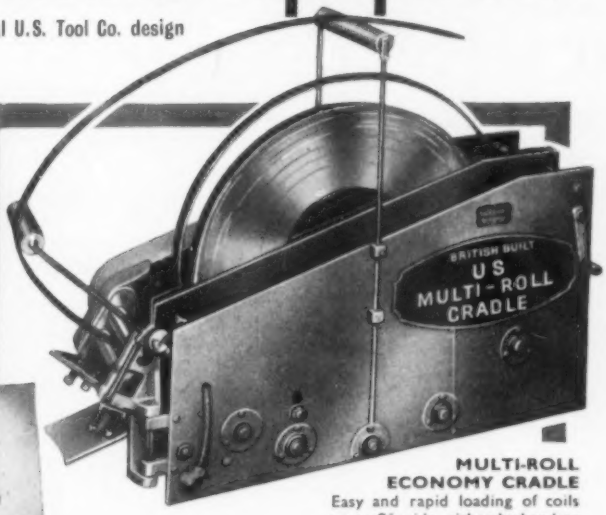
For use with slide feeds.



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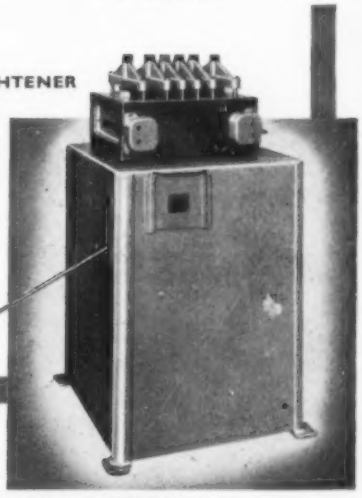

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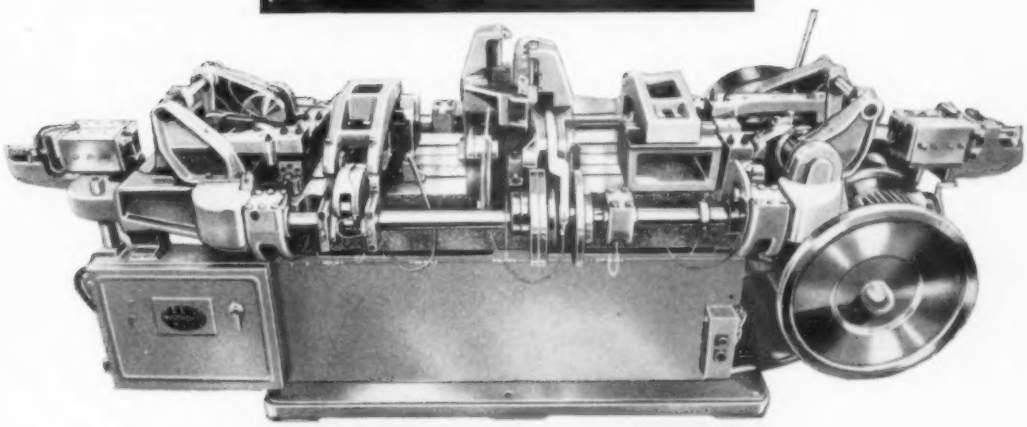

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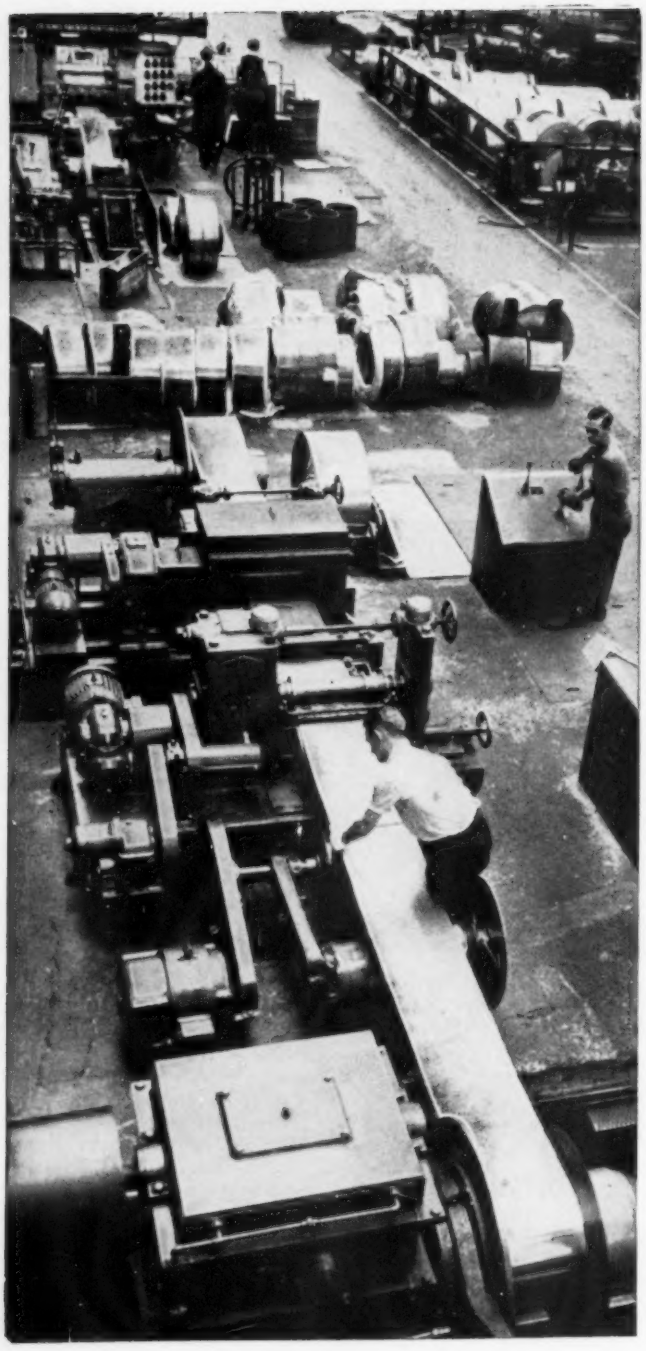
MK 6



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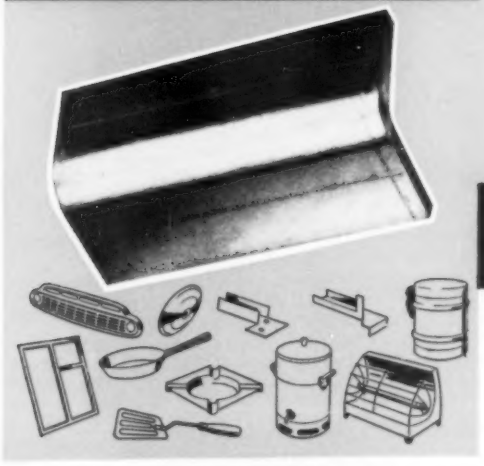

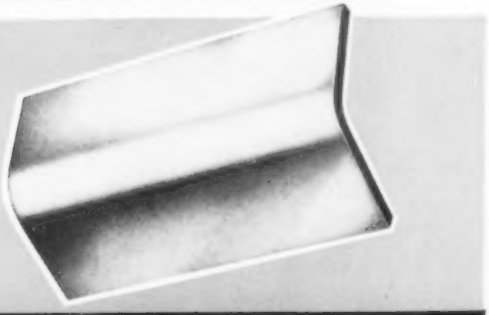

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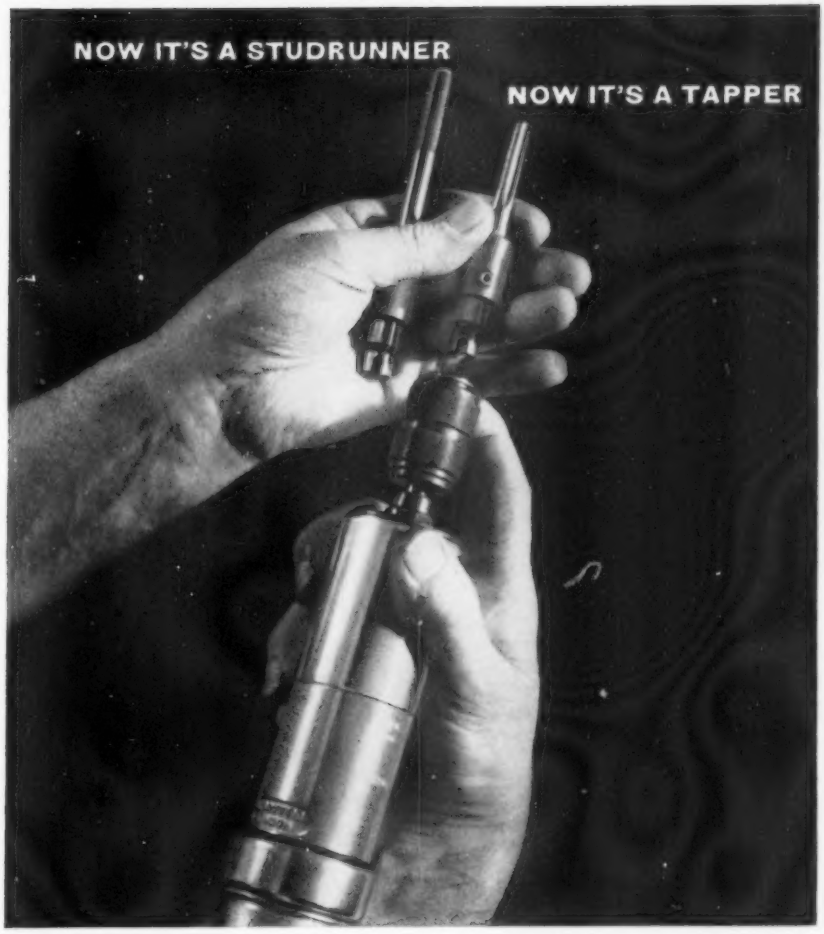

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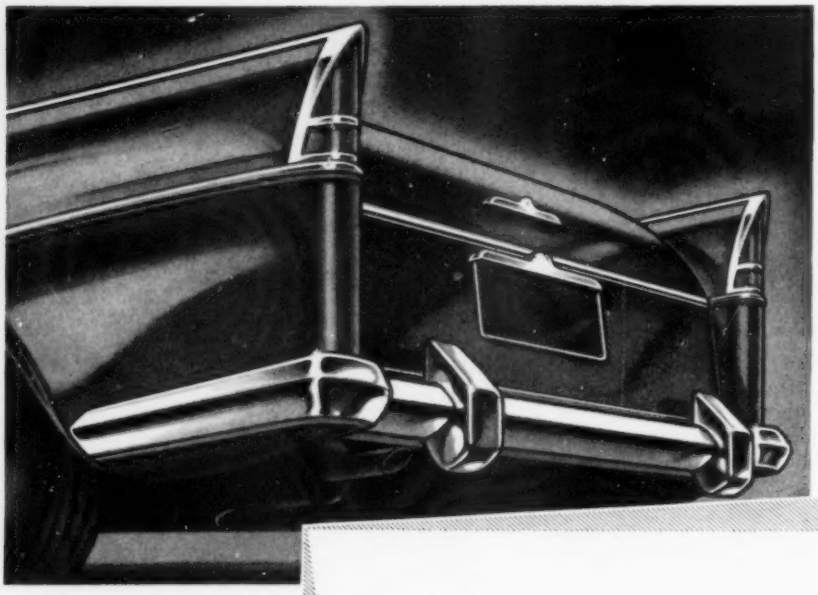

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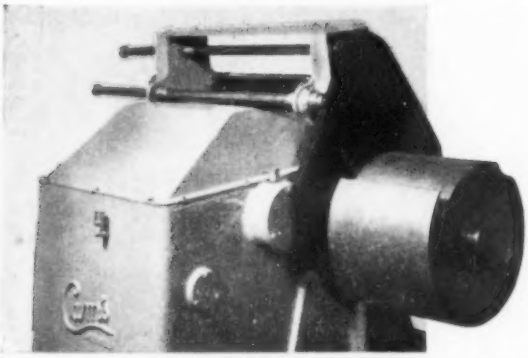

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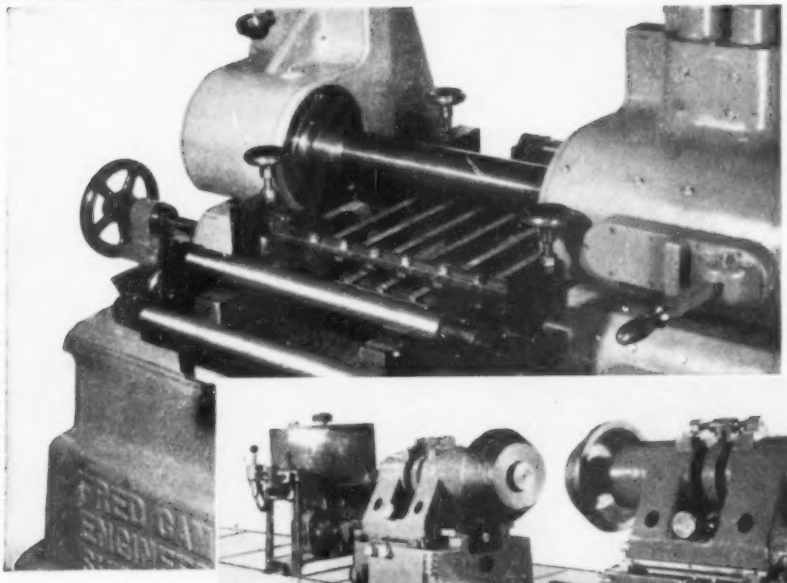

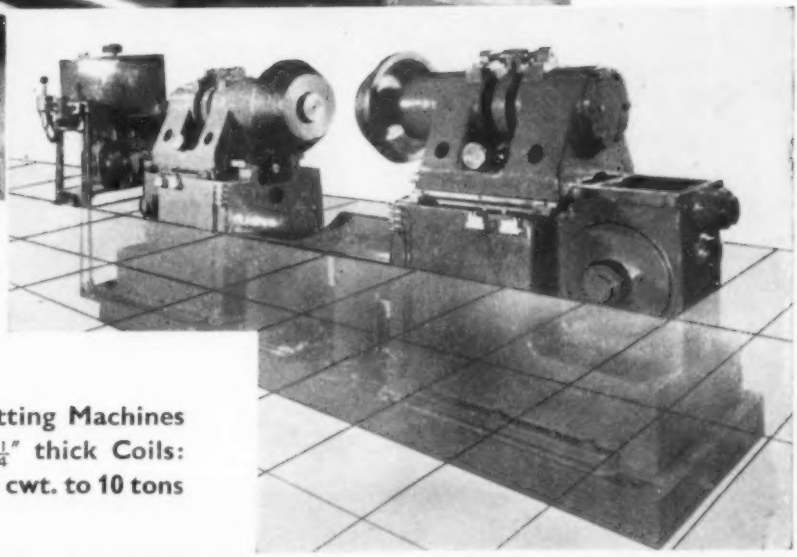

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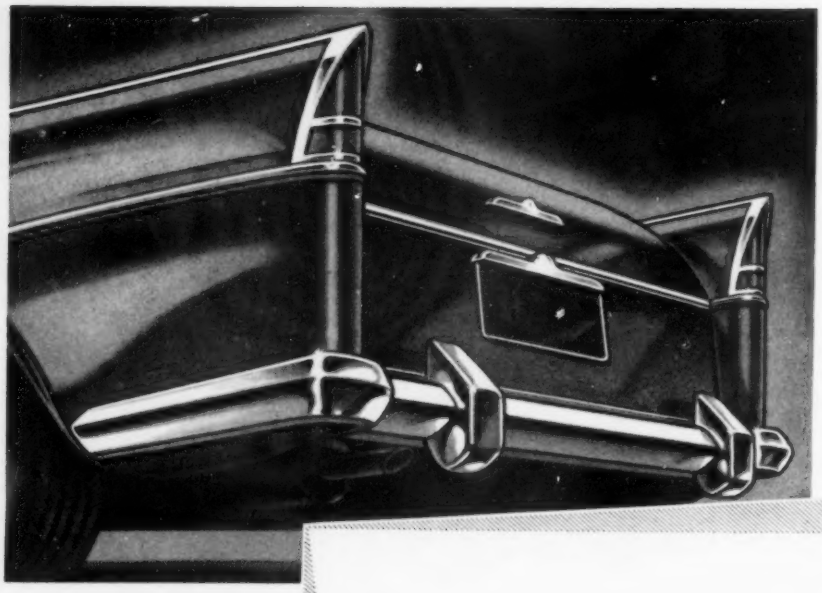

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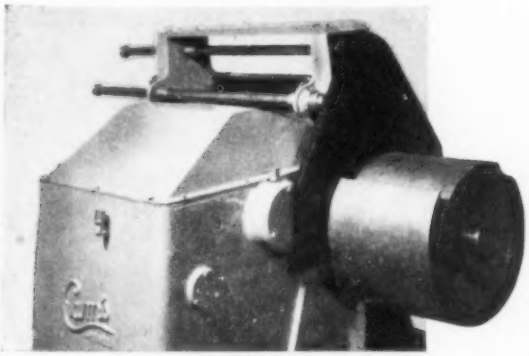

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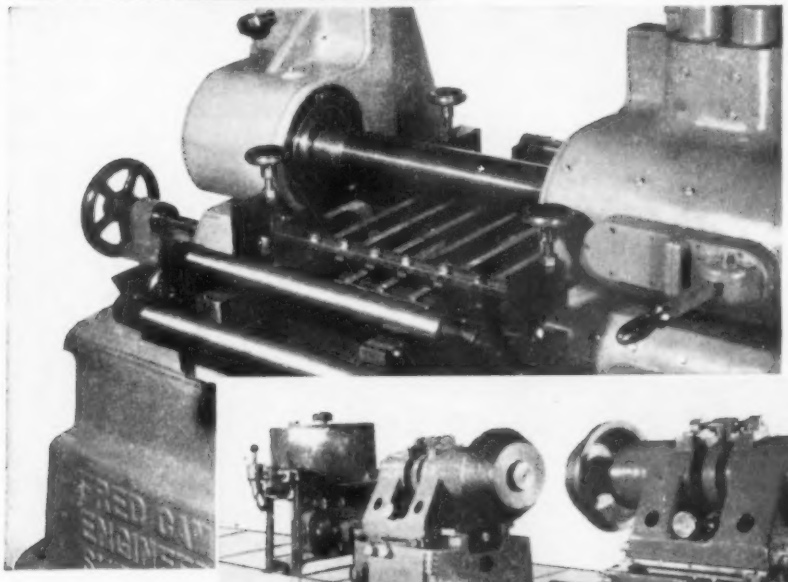

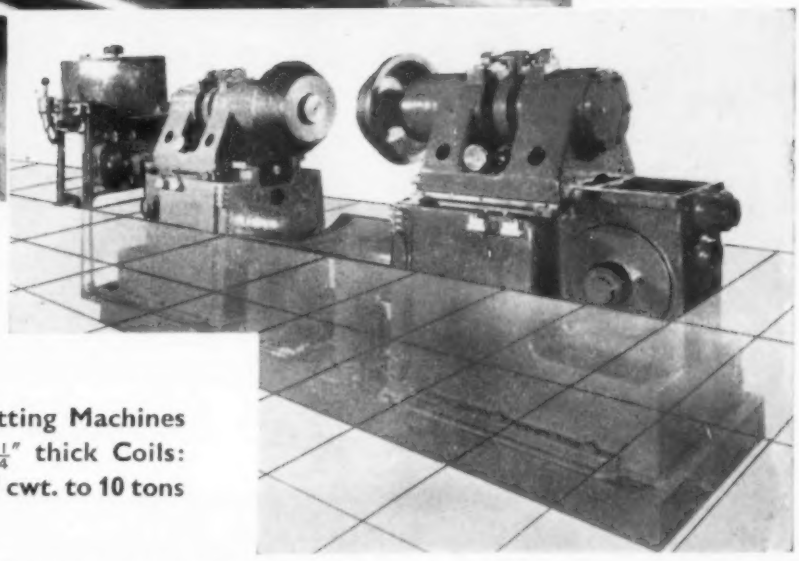

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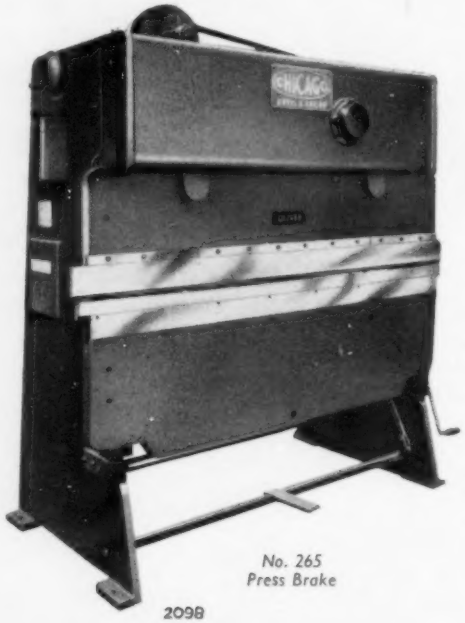

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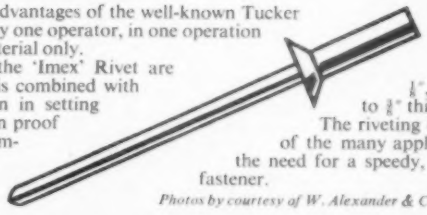

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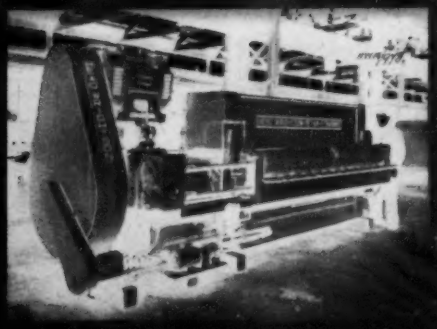
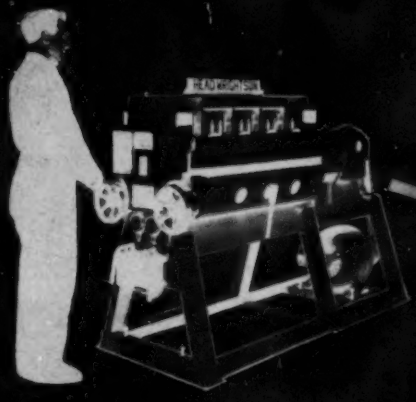
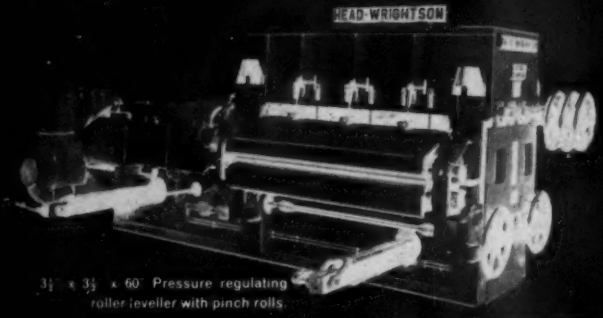


2½" x 2½" x 102" Processor leveller.

1⅛" x 1½" x 36" Pressure regulating roller leveller, with four banks of back-up rolls for levelling aluminium foil.





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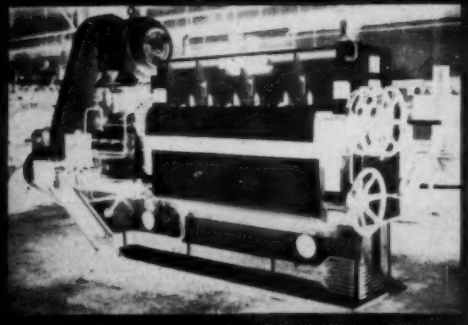
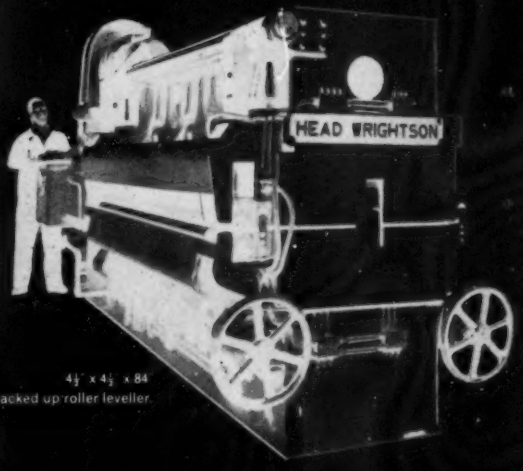
Three heavy plate levellers capable of levelling plate 12ft wide by 2 inches thick being built at the company's works.



1¾" x 1¾" x 54" Pressure regulating roller leveller.



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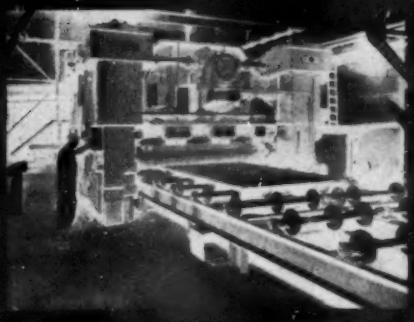
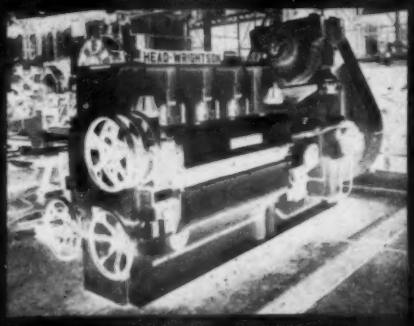
A heavy plate leveller in action at a shipyard handling plate up to 12' wide and 2" thick.





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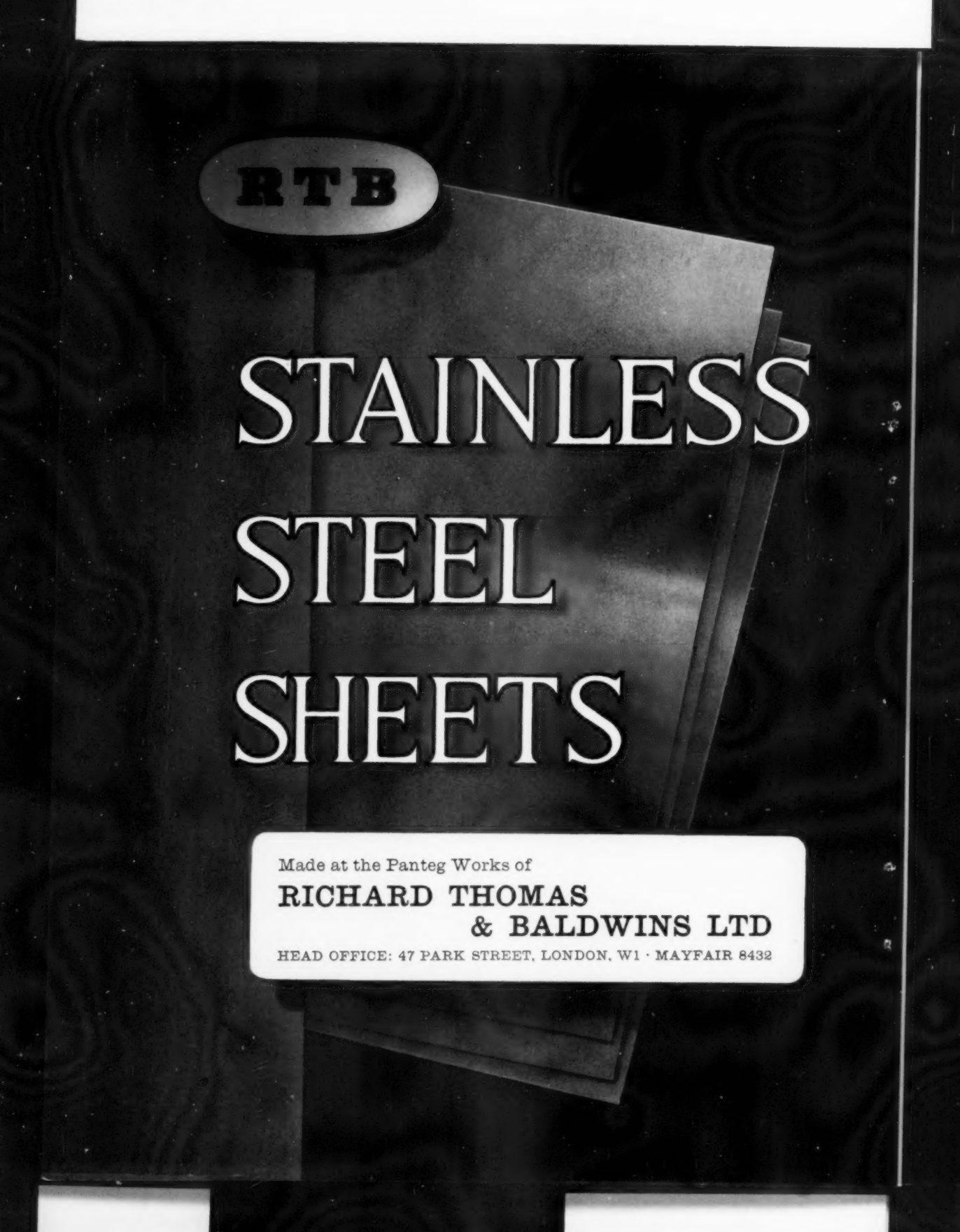
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Some Investigations into the Cold Extrusion of Steel 403
By F. Howard, A.M.I.Mech.E., H. A. J. Dennison, B.Sc., A.R.C.S., and N. Angus, A.Met., A.I.M.
Presented at the special conference on "The Cold Extrusion of Steel," organized by the Institute of Sheet Metal Engineering, this paper deals with extrusion load tests, condition of extruded components, extrusion tools and tool materials, preparation, heat treatment and lubrication of extrusion billets and slugs, lubrication of billets and slugs for cold extrusion, design of presses for cold extrusion, component design and application of cold-extruded components. The work reported in this paper was carried out at the Production Engineering Research Association of Great Britain, and also included is the discussion that ensued after the paper's presentation.

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"Power-and-Free" Conveyor System for Chrysler Body-Assembly Line 443
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Production of Power-Transformer Cores 449
Some details of a new core plate cutting machine installed by Ferranti Ltd.

An Introduction to the Theory and Practice of Flat Rolling—9 451
By the late C. W. Starling, B.Eng., A.M.I.Mech.E.
The general heading of this, the last chapter but one, of the late author's book is "Control of Physical Properties." Under this heading such subjects as control of width, gauge, length and cross-section are dealt with, and information is given on the equipment required to effect the required control. Also included is a section on surface finish in the hot-strip and cold-reduction mills.

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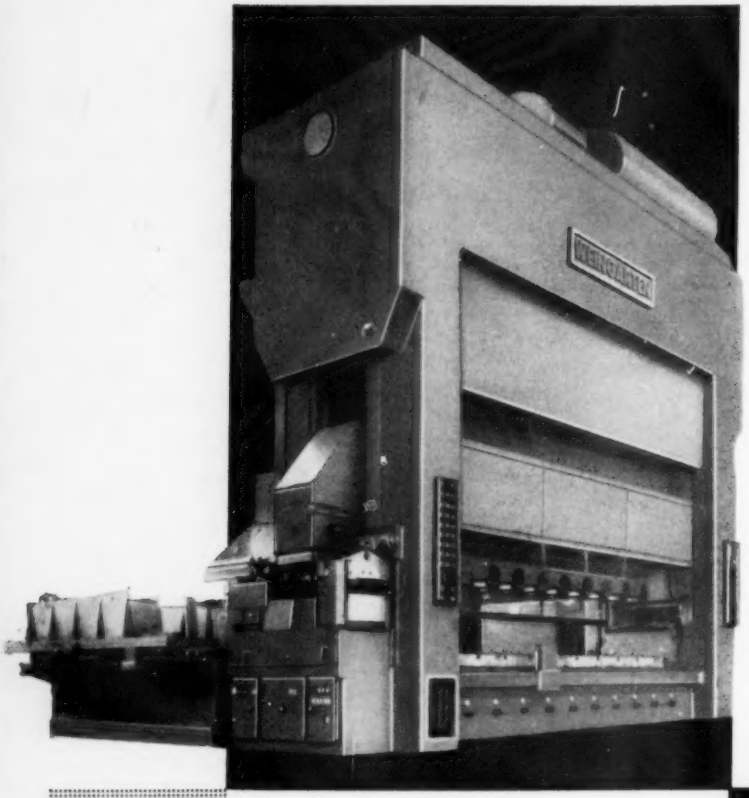

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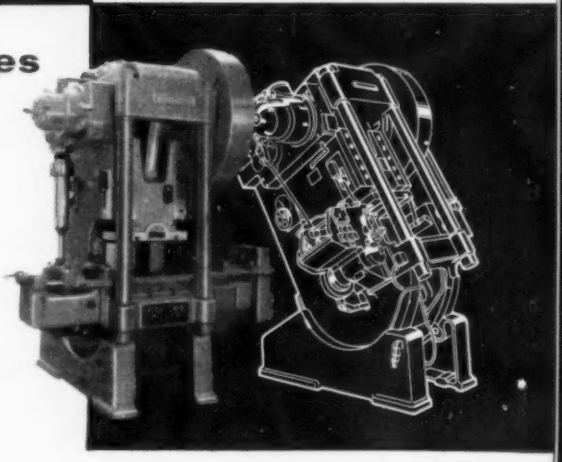

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RÉSUMÉS DES PRINCIPAUX ARTICLES

Quelques Recherches sur le Refoulage à Froid de l'Acier page 403

Par F. Howard, A.M.I.Mech.E., H. A. J. Dennison, B.Sc., A.R.C.S. et N. Angus, A.Met., A.I.M.

Présenté à la conférence spéciale sur "Le Refoulage à froid de l'Acier", préparée par l'Institute of Sheet Metal Engineering (Institut des Ingénieurs-Tôliers), ce mémoire traite d'essais de charges au cours du refoulage, de l'état des pièces refoulées, des outils employés au refoulage et des matériaux à outils, de la préparation, du traitement thermique et de la lubrification des billettes à refouler, de la lubrification des billettes pour le refoulage à froid, de la conception des presses pour le refoulage à froid, de la conception des organes et de l'utilisation des organes refoulés à froid. Le travaux faisant l'objet de ce mémoire ont été executés par la Production Engineering Research Association of Great Britain. Le débat qui a suivi la présentation de ce mémoire est également incorporé.

Systeme Transporteur "Power-and-Free" (Mécanique et Libre) pour la Chaine de Montage des Carrosseries dans l'usine Chrysler page 443

Cet article illustré décrit un nouveau système transporteur installé dans l'atelier d'emboutissage de la nouvelle chaine de montage de la Chrysler Corporation dans l'Ohio, U.S.A., servant à la fabrication des carrosseries "unitary" monocoques. Le "programming" incorporé du système transporteur, installé par la Link-Belt Company, rend entièrement automatiques de nombreuses opérations de manutention.

Introduction à la Théorie et la Pratique du Laminage à Plat—9 .. .. page 451

Par C. W. Starling, B.Eng., A.M.I.Mech.E. (décédé)

Le titre général de ce chapitre, l'avant-dernier du livre du regretté auteur, est "Le Contrôle des Propriétés Physiques". Sous ce titre, il y

(Suite page 460)

ZUSAMMENFASSUNGEN DER HAUPTARTIKEL

Einige Untersuchungen zum Kalt-Strangpressen von Stahl Seite 403

Von F. Howard, A.M.I.Mech.E., H. A. J. Dennison, B.Sc., A.R.C.S., und N. Angus, A.Met., A.I.M.

Dieser auf der Sonderkonferenz des Institute of Sheet Metal Engineering über „Kalt-Strangpressen von Stahl" als Vortrag gehaltene Artikel behandelt preßbelastungsprüfungen, den Zustand extrudierter Teile, Preßwerkzeuge und Werkzeugmaterialien, Vorbereitung, Wärmebehandlung und Schmierung von Knüppeln und Barren zum Kalt-Strangpressen, Konstruktion von Kaltstrangpressen, Entwurf und Anwendungen kaltgepreßter Teile. Die Untersuchungen wurden bei der Production Engineering Research Association of Great Britain durchgeführt. Die sich an den Vortrag anschließende Diskussion ist eingeschlossen.

„Power - and - Free" - Fertigungsstraße für die Montage von Chrysler-Karosserien Seite 443

Der bebilderte Artikel beschreibt eine neue, für die Fließbandfertigung von „Einheitskarosserien" im Preßwerk der Chrysler Corporation in Ohio, U.S.A., installierte Fertigungsstraße. Durch die von der Link-Belt-Company eingebaute Programmsteuerung werden viele der Arbeitsvorgänge vollständig automatisiert.

Einführung in die Theorie und Praxis des Blechwalzens —9 .. .. .. Seite 451

Von C. W. Starling†, B.Eng., A.M.I.Mech.E.

Die Hauptüberschrift dieses vorletzten Kapitels aus dem Buch des verstorbenen Verfassers heißt „Regelung der physikalischen Eigenschaften". Hier-

(Forts. S. 460)

RÉSUMENES DE LOS ARTICULOS PRINCIPALES

Algunas Investigaciónes Sobre la Extrusión en frio del Acero .. página 403

Por F. Howard, A.M.I.Mech.E., H. A. J. Dennison, B.Sc., A.R.C.S. y N. Angus, A.Met., A.I.M.

Presentada durante la conferencia especial sobre "La extrusión en frio del acero", organizada por el Instituto de Ingeniería de la Chapa Metálica, esta ponencia trata de las pruebas de carga de extrusión, estado de los componentes estrujados, herramientas para estrujar y materias primas para las mismas, preparación, tratamiento térmico y lubricación de lingotes y tochos para estrujamiento, lubricación de lingotes y tochos para extrusión en frio, concepción de prensas para extrusión en frio, modelaje de componentes y applicación de componentes estrujados en frio. Los trabajos de que trata la ponencia se llevaron a cabo en la Asociación de Investigación sobre Ingeniaria de Producción de la Gran Bretaña y se hace referencia también a la discusión de que fué seguida la presentación de la ponencia.

Instalación transportadora "A potencia y libre" para la línea de montaje de carrocerías de la Chrysler página 443

Este articulo ilustrado describe una nueva instalación transportadora instalada en el taller de estampado en Ohio, EE. UU. de A. de la nueva línea de montaje de la Chryslet Corporation y que ha sido instalada para la producción de carrocerías "unitarias". Un programado incorporado en el sistema transportador, que fuè ibstalado por la Link-Belt Company, hace que muchas de las operaciones de manipuleo sean completamente automáticas.

Una introducción a la teoría y la práctica de la laminación plana—9 .. .. página 451

Por C. W. Starling, B.Eng., A.M.I.Mech.E.

El titulo general de este penúltimo capitulo del libro del difunto autor es "Control de las Propiedades Fisicas". Bajo este titulo se trata de temas tales

(Continuara en p. 460)

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THE MISSING RUNG

THE aim of any system of education, whether the ultimate goal is towards the arts or the sciences, is to ensure that from early beginnings in the preparatory or primary schools, through the public or grammar schools, to the universities or colleges of technology, and beyond, a student can eventually qualify into, or further into, his trade or profession.

To-day, of course, particular importance is placed on further education, especially the colleges of technology, as it is the technologist who is so greatly in demand, but still in short supply. The advent of the forthcoming Commonwealth Training Week should assist in emphasizing the need for "education" and should also give the technical colleges an opportunity of strengthening their links with industry, schools, and young people. It is encouraging to know that the numbers of young people who are already taking further educational courses now stands at over two millions and that continual expansion of educational facilities has been confirmed by recent announcement of the setting up of four new universities.

To-day, there is no doubt that there are excellent opportunities at every level, and it is possible for everyone with the necessary ability and persistence to climb to the top. But even with these attributes the climb is not by any means smooth, as so often a student is compelled to sit for an examination the syllabus for which is so all-embracing that much time will be wasted on subjects not required.

To overcome this difficulty might at first appear to be an impossible task, but this is not so, as one qualifying institution has already made a survey of the extent to which subjects taught in certain courses were being used in industry by already-qualified people, and have designed a suitable training scheme for their students based on the results obtained. We hope that this will apply in the metallurgical field also.

But when a student qualifies and desires to keep abreast of the rapid developments in technology in his field he will be conscious that at the top of the technological ladder there appears to be a missing rung. This was referred to recently by Mr. E. W. Hancock, O.B.E., who, in his presidential address to the Institute of Sheet Metal Engineering, said that "the young men now coming through will be fully competent to deal with the problems of the future . . . but nationally we are not doing sufficient to give further education to adults."

To the man whose chosen path is one of practice, then in many cases he is able to keep up to date through his increasing practical experience, but the technologist whose knowledge is all important, in general relies on "refresher" and similar courses. Although this rung of the ladder is perhaps a little weak, it is not in fact missing altogether. The real omission is in the thoughts of those who feel that once qualified no further learning is necessary. That this attitude of mind is often met in those who direct industry is to be deplored, as keeping up to date should be the moral obligation of all.

Fig. 1.—The 600-ton press line showing the end to end mounting with clear and easy access to the front of each press, with inspection in left foreground

FIVE-TRANSFER FOR WHEEL

Some Details of at the Dagenham FORD MOTOR

A FIVE-PRESS transfer line is now in operation at the Dagenham Works of the Ford Motor Co. Ltd., for the production of car-wheel inners and similar components. The line was installed by Wilkins and Mitchell Ltd., Darlaston, and produces the component from prepared blanks in five separate operations, as shown in Fig. 1.

The presses have a capacity of 600 long tons, with a stroke of 14 in. They operate at 20 strokes per minute and have a bed cushion of 50 tons and a cam-operated top ejector. The ejector can be adjusted as near bottom of stroke as tools will allow. The pressing is ejected as the slide moves up, to leave the pressing on the bottom die.

The five presses are mounted on a continuous beam in the foundation, and are placed end-to-end at 10-ft. 10-in. centres, leaving the front and rear of each press free for hand operation and tool changes.

Although all operations are tied electrically, the presses " clutch " and " declutch " separately, and whether the transfer is operating or not the individual presses can be halted for inspection or maintenance.

The transfer equipment consists of a loader and loader slide, six magazines for blanks, four interpress slides, 24 clamp stations (for gripping the pressings) three of which in the present set-up are arranged for turning the pressings over, one extractor slide and chute, a drive unit for the whole line to provide right to left transfer motion, various brackets, bridges for dummy stations, guards and electrics.

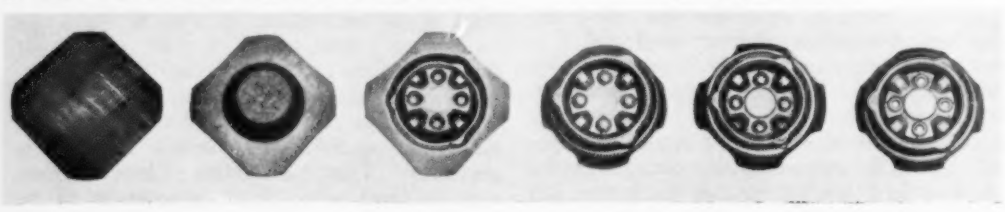
Transfer Sequence

Blanks are stacked at the blanking press in portable magazines, each of which will hold 150 blanks, or a 12-minute (approx.) run on the transfer. Magazines may be loaded by fork-lift truck or crane.

Three of these magazines which weigh approximately ½ ton each, are placed on the rotary table of the loader. This represents a total of 450 blanks for operation time of approximately 36 minutes.

The full magazines are usually loaded in pairs at

Fig. 2.—Five stages in development of Ford Anglia wheels from prepared blank



PRESS LINE CAR-INNERS

Equipment Installed Works of the COMPANY LTD.

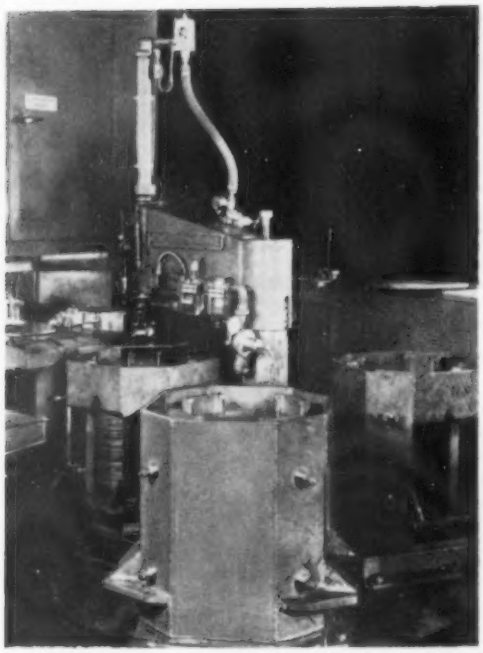


Fig. 3.—Blank-loader in operation showing method of magazine loading. Empty magazines can be easily replaced without interrupting the transfer sequence

regular 24-minute intervals. As a magazine becomes empty the loader table automatically revolves to the next magazine station, the blank is lifted from the top of the magazine and clamp shoes on the loader slide transfer it towards the first tool. Magazine loading is effected without interruption to the transfer sequence.

Transfer clamp stations number 24, five of which serve tools, while 19 are dummy stations to keep down the transfer travel to 26 in. Four interpress slides bring pressings through the presses to the last tool. These slides carry air cylinders, which actuate the clamps for holding pressings. Up to four stations may be arranged to invert pressings.

Finished pressings are ejected from the last press by means of an ejector slide and chute.

The transfer line moves from R to L, looking at the front of the presses. The blank lifting on the loader is done by air and the loader table rotates through 120 deg. by motor and gears. The clamp station shoes (to grip pressings) move by air but the turnovers are operated mechanically and are easily converted to normal stations without the removal of parts.

The whole transfer line is linked together and is driven by a single drive unit, positioned mid-way in the line. The drive is by motor, which runs continuously, being coupled by an electro-magnetic clutch and brake. (A secondary motor is provided for " inching " the line at one-tenth the transfer speed). The motion of the transfer slides is the same as that of the presses, *i.e.* little motion at start and finish of travel.

Checking

The feeding of two " adhering " blanks is detected by a gauging clamp at the second station. Misplaced blanks between presses are detected and the line is stopped.

Pressings are checked into and out of each press. The in-going pressing trips in the press only if the out-going pressing has cleared an interlocked safety circuit.

Means are also provided to ensure that each pressing is accurately located in the die. This check is operative and will " stop " the press, even though it has completed half of its stroke, but is shorted-out over B.D.C. (when " stickers " may otherwise result); visual indication is provided. The remainder of the line will complete the cycle and " stop " in the " start " position. If it is required to operate the press manually to complete an operation which has caused a " fault," the individual press control may be set to " single cycle " and the press operated by hand after the " re-set " button has been pressed.

If a single press is out of phase beyond the allowable limit, the presses cut out at the completion of the cycle.

(*Continued in page* 402)

Five-Press Transfer Line for Motor Car Wheels

(*Continued from page* 401)

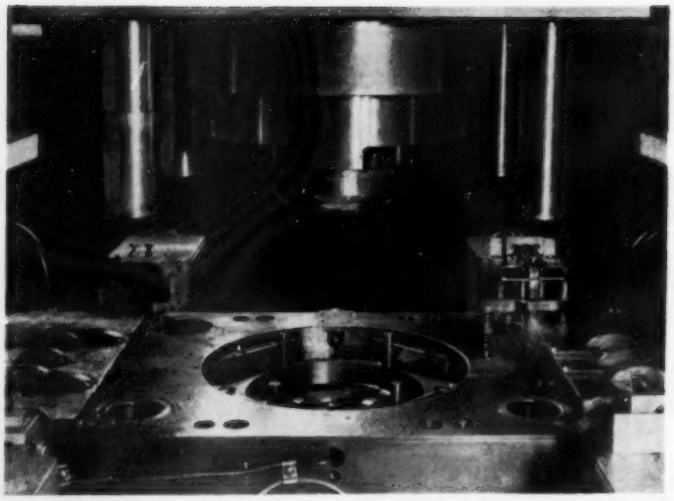


Fig. 4 (right).—Photograph showing the checking switches "in" and "out", the photoelectric "scanners" inserted in the die block, and the pneumatic lifters and clamping stations

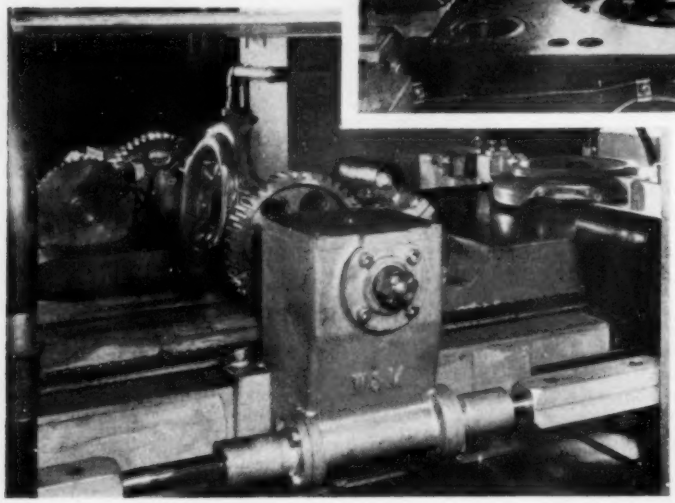
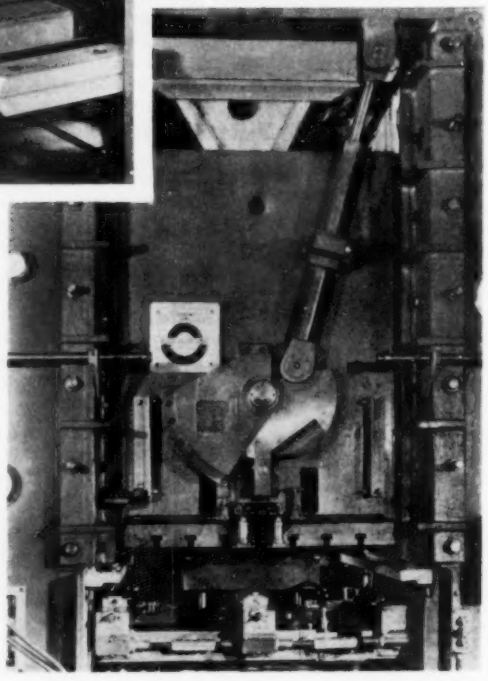


Fig. 5 (left).—A turnover station shown inverting a pressing

Fig. 6 (below).—Details of the top ejector. The cam face is shown in contact with the ejector bar which is supported by small pneumatic cylinders



The cycle " stop " button will allow the line to complete a cycle and stop in the correct position to re-start.

Emergency stops are provided all round and will stop presses and transfer *immediately*. To re-start, presses and transfer *must* be " inched " into the " start " position.

Although the presses appear to be of higher capacity than would be needed for the production of the component described, it is pointed out by Wilkins and Mitchell Ltd. that the Ford Motor Co. Ltd. insisted on standardization throughout the line so that lighter presses where they could have been justified were not installed. A further advantage of having all the presses the same is that of increased flexibility coupled with interchangeability. At a later date pressings of heavier gauge material will in all probability be produced on the line, so further justifying the installation of the heavier machines.

Some Investigations into the

COLD EXTRUSION OF STEEL

By F. HOWARD, A.M.I.Mech.E.,* H. A. J. DENNISON, B.Sc., A.R.C.S.* and N. ANGUS, A. Met. A.I.M.*

(A paper presented at the Special Conference on "The Cold Extrusion of Steel", organized by the Institute of Sheet Metal Engineering, and held in Sheffield, on November 21-23, 1960.)

Introduction

THE practical use of the process of cold extrusion of metal dates back over sixty years, when sheaths and tubes were made from lead, tin and other ductile materials. Subsequently aluminium and other non-ferrous metals were extruded, and the first reported application of the process to steel was in Germany over twenty years ago where its potentialities were soon recognized. During the last World War, considerable development took place in Germany, with the object of perfecting a satisfactory method for ammunition production which would permit more efficient material utilization than traditional methods of production. Since

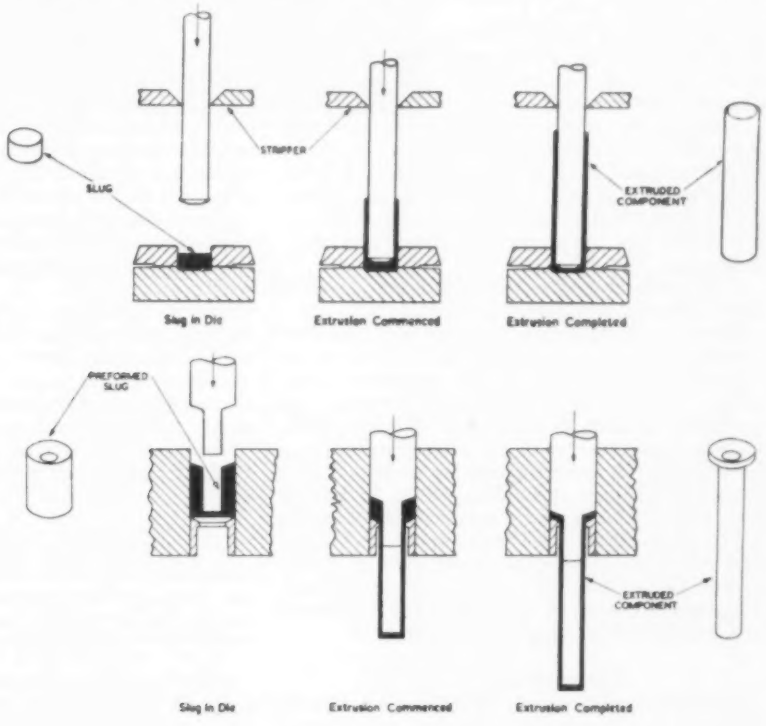


Fig. 1.—Two basic types of cold extrusion: (a) Backward; (b) forward

*Production Engineering Research Association of Great Britain.

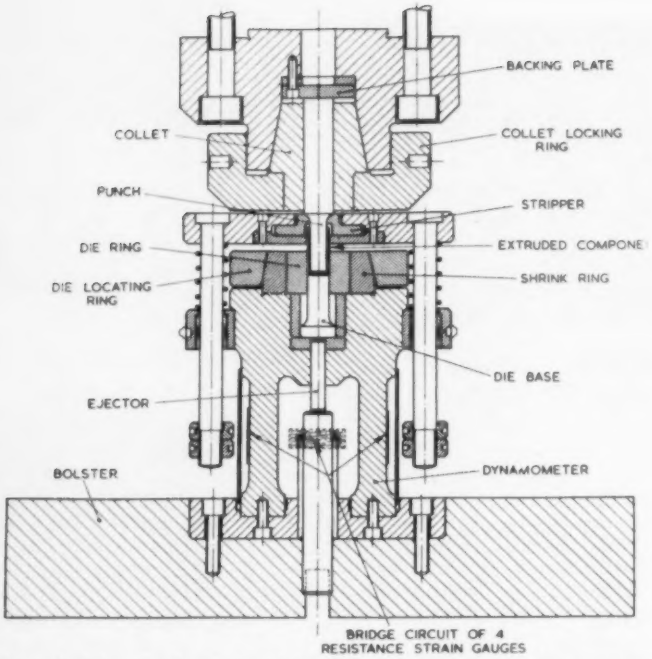


Fig. 2.—Backward extrusion tool and dynamometer

the end of the war, further work has been carried out in Germany and the U.S.A. to develop the process of cold extrusion for commercial applications and interest in the operation is now growing rapidly.

Although the term cold extrusion has been used in the title of this paper, many other terms including impact extrusion, cold pressing, heavy cold forging, extrusion pressing and cold forging, are in common use. The fact that no term is universally recognized emphasizes that the process is still in the development stage.

The operation itself is known sufficiently well to make a detailed description unnecessary.

However, depending on the shape of the required component, the metal may be deformed either by backward extrusion (Fig. 1 (*a*)), forward extrusion (Fig. 1 (*b*)), or a combinaton of forward and backward extrusion in one pressworking operation. In some instances, several extrusion operations may be required, or extrusion may be combined with other pressworking operations such as re-drawing and ironing. Components produced by extrusion can be of circular or non-circular section and, in the case of hollow components, there may be a base or shoulder formed at one end of the component. In general, the material is caused to flow axially into a shape and size governed by the tooling.

Extrusion Load Tests

The first requirement for any cold-forming operation is a knowledge of the forces involved in the process, particularly in relation to the loads likely to be imposed on the tooling.

A range of extrusion tools, suitably instrumented, was therefore constructed to give reductions in area during extrusion from 40 per cent to 80 per cent. A sectional drawing of the tooling used for backward extrusion is shown in Fig. 2, and the 120-ton crank press used for the tests is shown in Fig. 3.

These tools have been used to obtain values of maximum extrusion pressures at various reductions for a large number of plain-carbon and low-alloy steels. For example, Fig. 4 shows graphically the results obtained for a series of low-carbon steels in the annealed condition. These results are expressed as the maximum punch pressure at various percentage reductions in area. However, if one relates the extrusion load to the die base area it is possible to plot the values obtained as maximum extrusion pressure against the ratio of the original slug area to the extruded wall area, *i.e.* the extrusion ratio $\frac{A_o}{A}$.

This has been done in Fig. 5 and by using a logarithmic scale, approximately linear relationships are obtained. The straight lines drawn to suit the results, which actually appear to lie on a slight curve, have equations of the form :

$$P = a \log_e \frac{A_o}{A} + b$$

where P is the extrusion pressure and a and b are

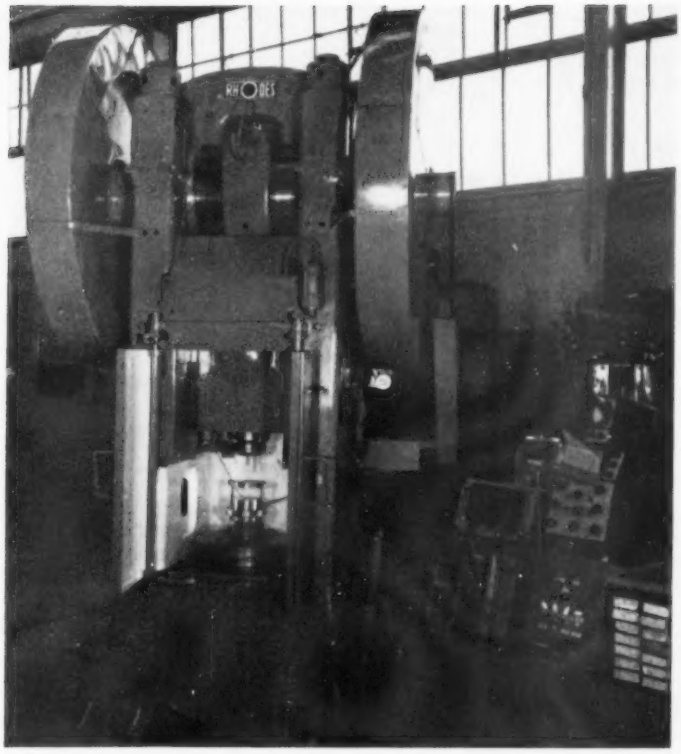
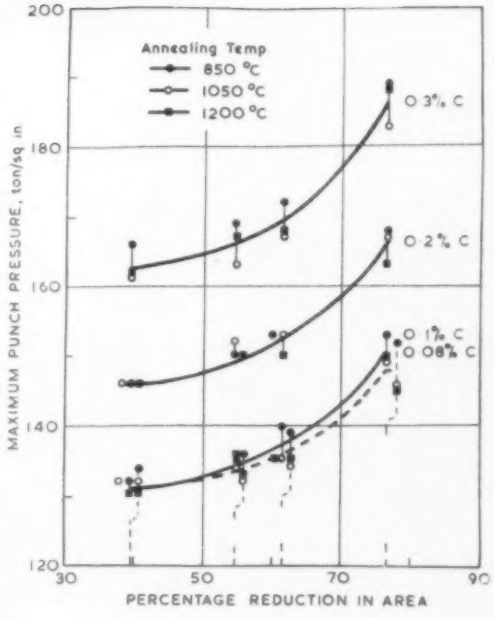


Fig. 3 (left).—Extrusion press and recording equipment

Fig. 4 (below).—Maximum punch pressures for annealed low-carbon steels



constants depending on the nature of the work material.

For the three steels shown in Fig. 5 the equations are :

$$0.3 \text{ per cent C.P} = (80 \log_e \frac{A_0}{A} + 25) \text{ tons per sq. in.}$$

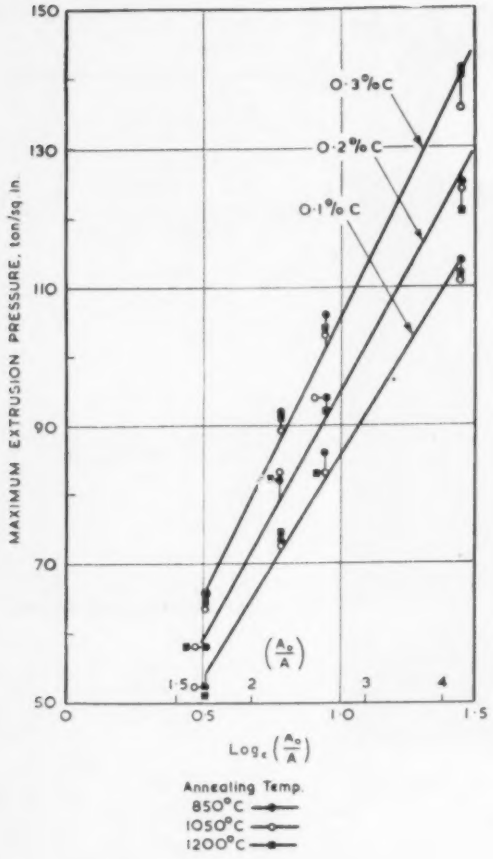
$$0.2 \text{ per cent C.P} = (71 \log_e \frac{A_0}{A} + 23) \text{ tons per sq. in.}$$

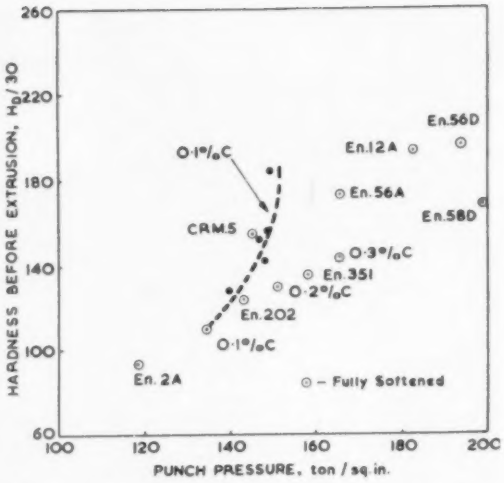
$$0.1 \text{ per cent C.P} = (63 \log_e \frac{A_0}{A} + 22) \text{ tons per sq. in.}$$

It has been found that these three equations can be closely approximated by a single equation :

$$P = Y (3.45 \log_e \frac{A_0}{A} + 1.15) \text{ tons per sq. in.}$$

where Y is the upper yield point for each material in the annealed condition. As far as is known there is no explanation for the extrusion pressures being proportional to the upper yield points and the results may not be applicable for other materials.





Johnson[1] has suggested, however, that a mean yield stress derived from an appropriate dynamic stress/strain curve of the material can be used in an equation of the form given.

It would be very convenient if some simple mechanical test, such as a hardness test, could be used to give some indication of the pressures needed for extrusion. In Fig. 6 the hardnesses of a range of materials are plotted against the pressures required to reverse extrude them at a particular reduction. The points ringed indicate that the material was fully softened before extrusion.

The low-carbon and low-alloy steels appear to lie in a reasonably narrow band—the dotted line shows the general trend of hardness against punch pressure for a 0.1 per cent C steel under various conditions of heat treatment and pre-straining. However, the points for the higher alloy steel are rather widely scattered, which is probably explained

Fig. 5 (above).—Variation of extrusion pressure with carbon content

Fig. 6 (top, right).—Effect of slug hardness on punch pressures for backward extrusion at 54 per cent reduction

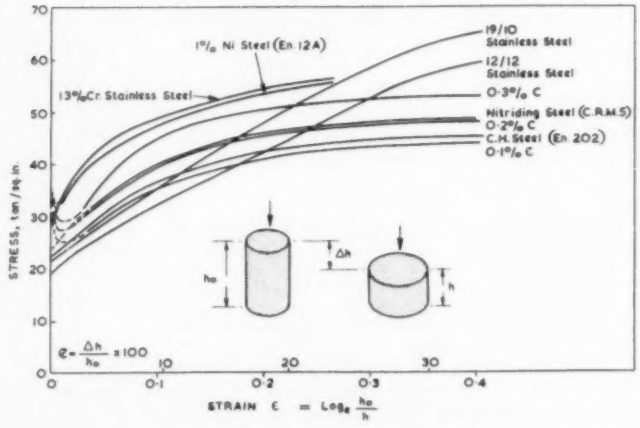


Fig. 7 (right).—Dynamic compressive stress-strain curves for a range of steels. (Mean strain rate = 7)

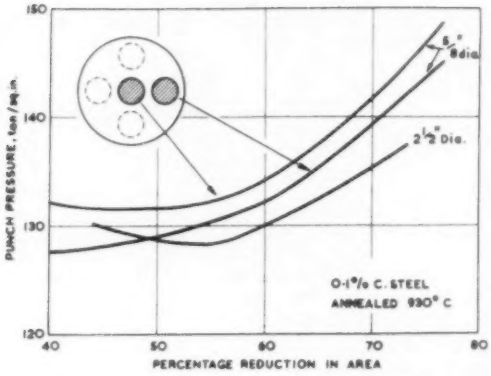


Fig. 8 (above).—Effect of component size on punch pressures (backward extrusion)

by the differences in form of the material stress-strain curves. When it is appreciated that the hardness test produces a mean strain of about 8 per cent whereas during extrusion the metal is strained by at least 50 per cent, it follows that the material with a stress-strain curve which remains almost flat after yield will not necessarily extrude at the same pressure as one which has a similar yield but a high capacity for strain hardening. For example, the 12/12 austenitic stainless (En 58D) required a very high pressure compared with a low-carbon steel of the same hardness (200 tons per sq. in. compared with 150 tons per sq. in.)

Fig. 7 shows the dynamic stress-strain curves for some of the materials obtained for a strain rate similar to that pertaining during the extrusion tests,

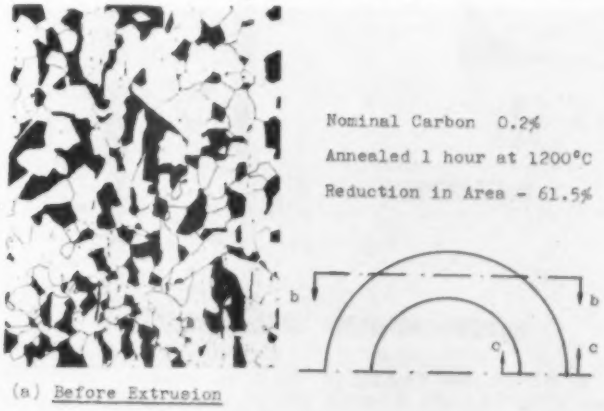


Fig. 9 (x 100)(right).—Change in structure of low-carbon steel due to cold extrusion

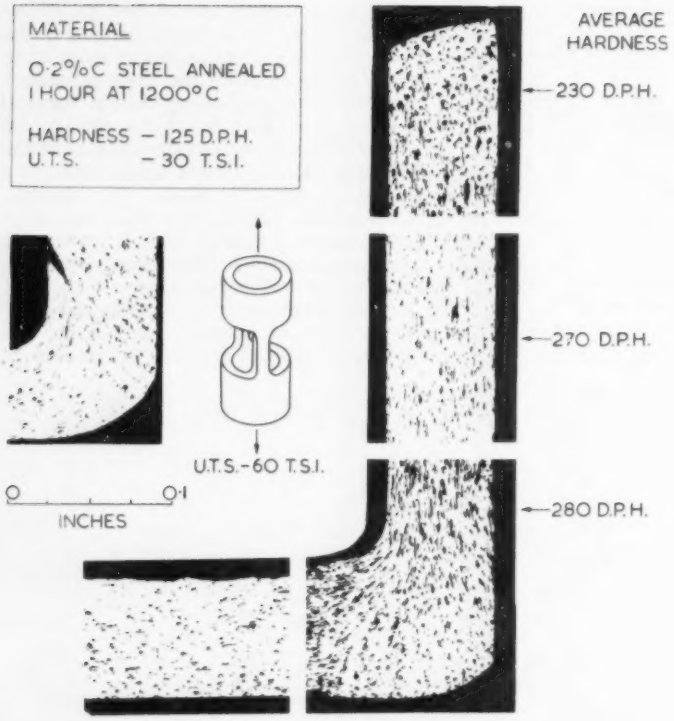


Fig. 10 (× 20).—*Change in structure and properties due to cold extrusion (reduction in area* 61.5 *per cent)*

It will be seen that for the austenitic stainless steels, from a low yield stress, and therefore a low hardness value, a very high degree of strain hardening occurs, so that the area under the curve for strains greater than 30 per cent is considerably greater than for other materials. This area under the curve gives the work done during deformation and therefore determines the extrusion pressure.

It has been found that a reasonably linear relationship exists between extrusion pressures and the dynamic compressive strength at about 40 per cent strain, obtained from these stress-strain diagrams. Test results for softer non-ferrous metals have also fitted the relationship quite well.

If the strain rate is reduced it would be expected that the value of the dynamic yield strength would decrease. Tests recently completed, using a slower acting press and large-diameter slugs ($2\frac{1}{2}$ in. dia. compared with $\frac{3}{8}$ in. dia.) tend to show this effect.

Fig. 8 shows the punch-pressure reduction curves for the 0.1 per cent carbon steel backward extruded into $2\frac{1}{2}$-in. dia. cups at 5.8 in. per sec. compared with those for $\frac{3}{8}$-in. dia. cups extruded at 10 in. per sec. For these tests all the slugs were machined from the same bar of annealed steel. As results obtained by the National Engineering Laboratory(4) have shown little significant differences in extrusion pressure due to extrusion speed in the range shown in Fig. 8, these present results may be attributed to variations in strain rate due to size of the extrusion.

The variation in results for small slugs machined from the outer regions of the bar compared with those from the centre is interesting and is probably a reflection of segregation effects in bar.

Condition of Extruded Components

During the course of the experiments with low-carbon steels some metallographic observations were made on the structures of the extruded cups. Fig. 9 shows the grain structure in the wall of an extruded cup. The upper micrograph shows the original structure before extrusion and below are the views of the deformed structure taken on tangential and radial planes at the same magnification. The flow of the material in reverse extrusion is such that the grains are extended both circumferentially and longitudinally to form thin plates. This is quite distinct from the structure produced by forward extrusion where the metal flows radially inwards to the die orifice and the grains are elongated to a needle-like form.

Macrographs taken on a section of the wall and base of a reverse extruded cup are shown in Fig. 10. With an initial hardness of 125 DPH and an

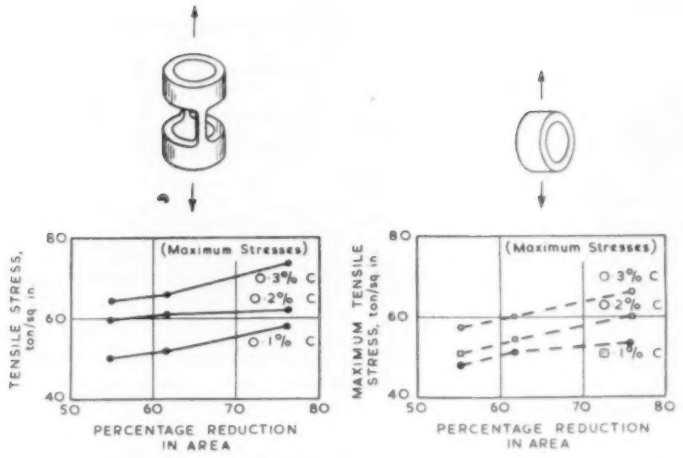


Fig. 11 (left).—Results of axial and hoop tensile tests on extrusion walls. (Plain carbon steels annealed at 850° C.)

Fig. 12 (below).—Bore contour of extruded cup (46 per cent reduction)

ultimate tensile strength of 30 tons per sq. in. the walls have hardened up to between 230 and 280 DPH and have a tensile strength of 60 tons sq. in.

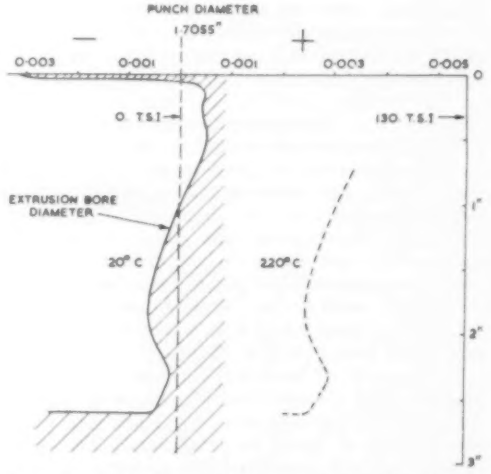
The result of penetrating too far into the slug and leaving too thin a base with this type of tooling is shown also in Fig. 10. This view is of the bottom corner of the extruded wall where the base thickness has become less than the wall thickness. The metal is strained in tension on the inner surface after flowing round the punch and a crack is formed.

One advantage of cold extrusion is the increased strength of the extruded component. Special tests were devised to enable strength measurements to be made on the walls of the comparatively small backward-extruded cups produced in the experiments. Rings were cut from the walls and pulled between semi-circular anvils to measure the hoop strength. For the axial tests, the wall of the extrusion was cut away as shown in Fig. 10, to leave two diametrically-opposed test sections. The difference in strength in the two directions was found to be small. The results for three low-carbon steels are shown in Fig. 11.

Other workers[3] have shown that the general level of impact strength for a non-ageing steel remains high after extrusion. With a steel sensitive to strain-ageing low impact strengths are reported after extrusion at low reductions, but the toughness increases rapidly above about 60 per cent reduction.

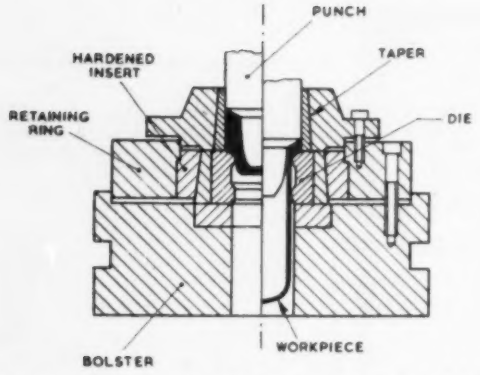
The dimensional accuracy obtainable in an extrusion is determined by the initial accuracy of the tooling and the wear that occurs during its useful life, the distortion of the tools and the component under the working stresses and due to the considerable temperature changes, and finally the accuracy of location between the upper and lower tooling.

A discussion of all these factors is outside the scope of this paper but a simple illustration of the effects



of elastic distortion and temperature change on the final form of a reverse extruded cup may be of interest.

Fig. 12 shows the measured profile of the bore of a backward-extruded cup, at greatly increased horizontal magnification. The mouth of the cup is at the top of the diagram. The diameter of the punch which formed the cup is also shown on the same scale. Under the extrusion load the punch compressed elastically by about 1 per cent or 0.010 in. per in., and expanded diametrically by about 0.003 in. per in. Hence the increase in diameter of the punch was about 0.0055 in. during extrusion. There was some elastic contraction of the extrusion wall after its formation, and before cooling from about 200° C. the bore diameter would have been about 0.003 in. greater than the final diameter, as indicated by the dotted line. In fact



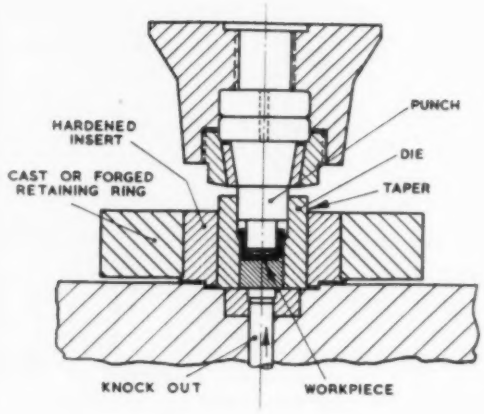


Fig. 13.—*Typical tooling for cold extrusion of steel (a) (above) forward extrusion*[4] *(b) (right) backward extrusion*[5]

immediately after extrusion, and when still hot, the component could slide freely over the whole punch length and only the narrow lip at the extrusion mouth engaged with the land on the punch.

Extrusion Tools

The tooling for cold-extrusion operations varies in design according to the demands which will be placed on it; this depends mainly on the material being extruded and the degree of deformation required. From what has been said already tooling for steel extrusion requires to be very robust to withstand the severe extrusion forces.

Typical tooling for forward and backward extrusion of steel, taken from previously published sources, is shown in Figs. 13 (a) and 13 (b).

In the case of backward-extrusion tooling, the length of the punch should be kept as short as possible and in most cases a length/dia. ratio of not more than 4 : 1 should be maintained. The punch should be well supported by a collet or other suitable holder. When high product accuracy is required it is desirable, if possible, to provide a bushing to guide the punch during the operation. Punches provided with such support have been used successfully when the length/dia. ratio has been as high as 6 or 7 : 1.

Solid dies are susceptible to cracking at the junction of the die wall and the base and therefore it is good practice to support the die wall by shrunk-on outer rings.

The relative dimensions of the die and shrink rings are usually determined by the use of Lame's formulæ for stresses in thick cylinders.

As the shrink rings are continuously under tensile hoop stress, generally in the region of 30 tons per sq. in. in the standing condition and rising to about 45 tons per sq. in. under extrusion pressure, high-tensile steels are needed for their manufacture and from experience it has been found necessary to use well-forged steels, preferably ring forgings for the larger sizes. Every care should be taken to keep the hydrogen content of the steel as low as possible as hydrogen is thought to promote failure by "static fatigue". A typical example is shown in Fig. 14. Fractures such as this can occur when the die is not in use and sometimes as long as twelve months after the ring has been shrunk on to the die.

This type of die construction is particularly applicable to cemented-carbide dies, which have excellent wear-resisting properties and give good tool life when adequately supported.

Most punches and dies are manufactured from high-grade tool steels such as high-carbon, high-

Fig. 14.—*Fractured shrink ring*

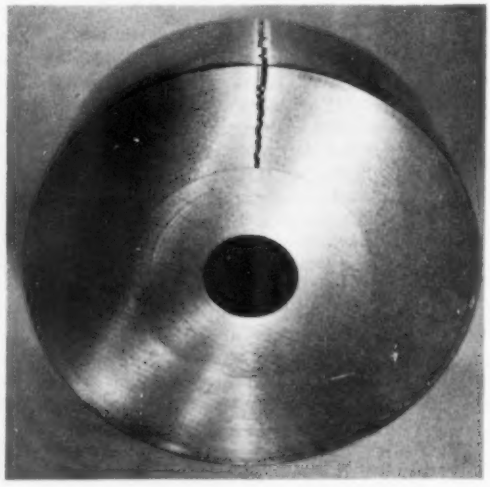


TABLE I—*Tool Materials for Cold Extruding Steel*

Tool Material	Application	Composition (per cent)								Rockwell Hardness
		C	Si	Mn	Ni	Cr	Mo	V	W	
High-carbon High-chromium Tool steel	Die inserts and Medium-stressed Punches	2.10	—	0.30	—	12.0	1.0	0.25	—	C60–62
		1.6	—	0.40	—	13.0	1.0	0.25	—	C58–60
High-speed steel	Highly-stressed Punches	0.80	—	—	—	4.2	5.0	2.0	6.0	C64–66
		0.75	—	—	—	4.0	—	1.0	18.0	C64–66
High-tensile steel	Tool holders and Bolsters	0.35	0.35	0.7	2.8	0.8	0.7	—	—	C44–46
Shock-resisting steel	Ejectors and Die Bases	0.48	0.7	0.35	0.70	1.5	0.25	0.12	1.2	C56–58
High-tensile steel	Shrink Rings	0.34	0.35	0.60	4.3	1.4	0.40	—	—	C44–48

chromium tool steel and high-speed steel which under favourable conditions will give up to 240 tons per sq. in. compressive strength. However the ability of a tool steel to withstand alternating loads at temperatures up to 300° C. is of paramount importance and selection of the appropriate steel should be made with this in mind. A list of some of the popular types of tool steel is given in Table I.

In addition to tool material selection, the subsequent heat treatment of the tooling is very important.

Most people advocate that punches and dies should be conventionally hardened and tempered to Rockwell C 60 to 62, but views have also been expressed that the hardness of punches should be increased to Rockwell C 66 in order to obtain greater resistance to buckling under the extrusion forces.

Significant increases in the tensile properties of punches have been achieved at PERA by using a sub-zero treatment to reduce the amount of austenite retained after quenching. Substantially the treatment consisted of placing the punch into a freezing mixture immediately on cooling to room temperature; holding it at —80° C. for two hours, warming in air to room temperature and then heating it steadily to the tempering temperature. A number of variations of this treatment were tried and some of the results are shown in Fig. 15.

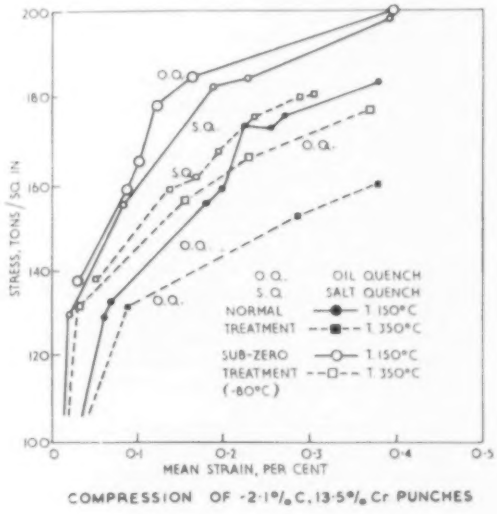
Each punch was given steadily increasing dynamic loads by extruding materials of increasing hardness, and measured after each load application. From the results a type of "stress-strain" curve was constructed for each punch. It can be seen that the punches which received the sub-zero treatment sustained substantially higher loads than those subjected to more conventional treatment. This treatment has been used with considerable success on slender punches which were right on the top limit of length dia. ratio.

Tool geometry for both backward and forward extrusion is an important factor that can have a considerable influence on tool loadings and the quality of the product. The results of PERA experiments on the effect of the die entry angle on the maximum pressure required to forward extrude a carbon steel are shown in Fig. 16. It will be seen that the extrusion force decreases as the die entry angle decreases but that there is a small increase in stripping force.

Experiments have also been carried out using a variety of punch nose shapes, a selection of which is shown in Fig. 17.

Significant differences in punch pressures were found for the different punch profiles tested.

Fig. 15.—Effect of sub-zero treatment on the mechanical properties of punches



COMPRESSION OF ·2·1% C, 13·5% Cr PUNCHES

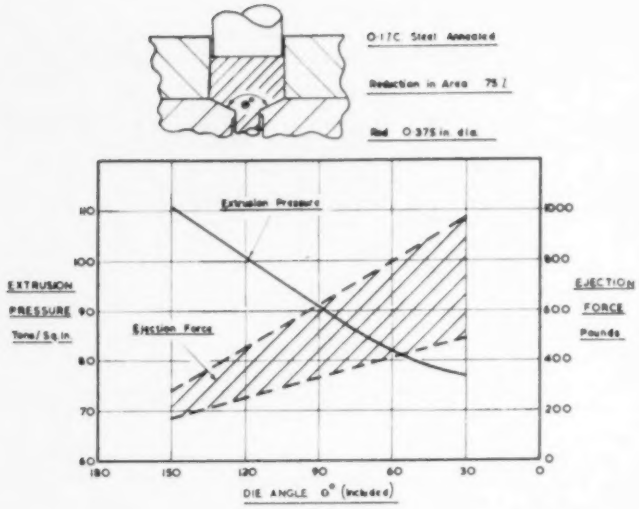


Fig. 16 (left).—Effect of die angle on extrusion pressure and ejection force

Fig. 17 (below).—Experimental punch-nose shapes for backward extrusion

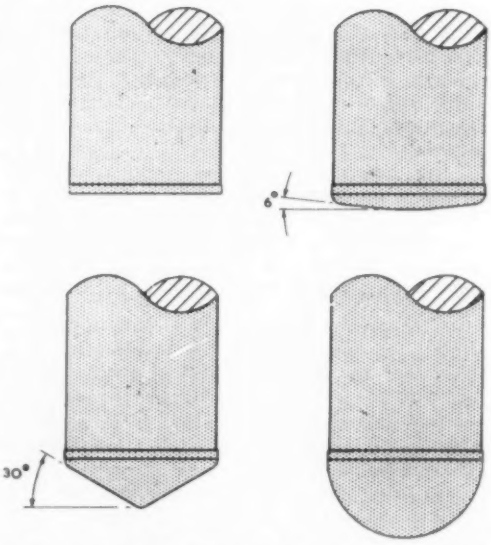


Fig. 18 shows some of the results obtained.

One important factor emerging from these tests was the tendency of the conical and dome ended punches to penetrate the phosphate coating particularly towards the end of the extrusion process. Thus to avoid the possibility of "pick-up" occurring punches with similar profiles to these should be used only when a shallow extrusion is required.

Preparation, Heat-treatment and Lubrication of Extrusion Billets and Slugs

One of the main advantages in adopting cold extrusion as a method of manufacture, is the potential saving of material, and the production of extrusion billets with the minimum waste is therefore of great importance.

The principal methods of manufacture of slugs are shown in Fig. 19 which also gives some indication of the material utilization and billet proportions suited to the particular process.

While the most extensively used method is still probably machining from bar, cropping and coining is finding increasing application particularly for the manufacture of general engineering components requiring no high degree of surface finish. Besides achieving 100 per cent utilization of material, this process has the added attraction that it can be conveniently incorporated in a production line or in a special-purpose cold-forming machine. In the latter case, however, it would be preferable if the annealing and phosphating operations could be omitted.

The results of PERA experiments on backward extruding prestrained slugs both before and after annealing is shown in Fig. 20. It will be seen that the effect of annealing at 700 C. has been to reduce the punch pressures for the 20 per cent strained material to within 1 per cent of the annealed mean curve level.

At first sight, the significantly increased pressures required to extrude the prestrained unannealed slugs would appear to be prohibitive, but it should be borne in mind that these tests were carried out at room temperature.

Recent PERA experiments using prestrained slugs heated to 200/250° C. and extruded in a cold die have shown that if the extrusion can be carried out while the prestrained slug is hot, the pressures

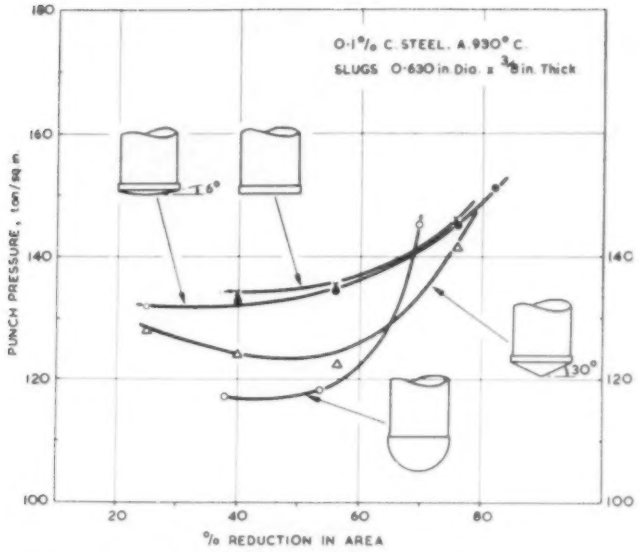


Fig. 18 (left).—Effect of punch contour on punch pressures

Fig. 19 (below, left).—Production of extrusion billets

Fig. 20 (below, right).—Effect of prestraining and annealing on maximum punch pressure for 0.1 per cent carbon steel

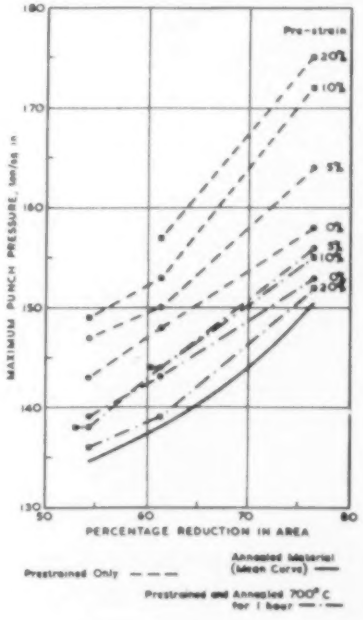
required are not greatly in excess of those for annealed material extruded at room temperature (Fig. 21).

If the coining operation can be carried out under conditions which give high rates of strain it is known that considerable strain heating can occur so that it is possible that this may be used to reduce subsequent extrusion pressures providing that the extrusion follows immediately on the coining operation.

Experiments have shown this to be so and slugs which have been coined rapidly to approximately 40 per cent strain and then immediately extruded have given punch pressures significantly lower than for slugs coined, allowed to cool and then extruded. This is seen clearly from the load traces shown in Fig. 22.

There is sometimes an advantage to be gained in carrying out the extrusion operation with heated slugs or billets. This applies particularly to materials which rapidly work-harden.

METHOD	MATERIAL UTILISATION	SIZE RANGE	
		DIA.	LENGTH DIA.
MACHINE FROM BAR Hot Rolled - Turn & Part Off C'less Ground } Part Off or Slit Bright Drawn }	70%-90%	Full Range	$> \frac{1}{2}$
CROP FROM BAR Coin to Size and Anneal	100%	$\frac{1}{2}$ in. to $1\frac{1}{2}$ in. After Sizing	$> \frac{1}{2}$
BLANK FROM FLAT BAR Anneal	40%-60%	$\frac{1}{2}$ in. to $1\frac{1}{2}$ in.	$< \frac{3}{4}$



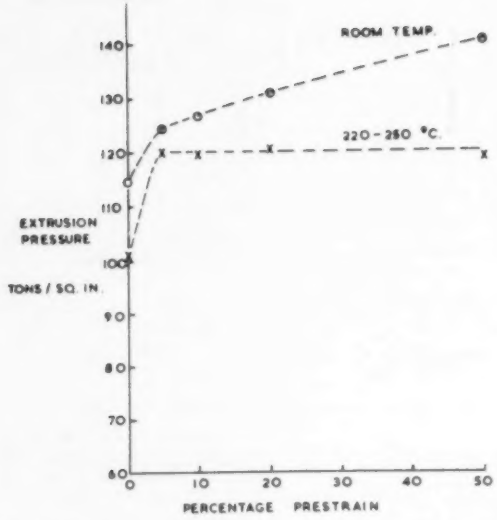


Fig. 21 (above).—Effect of prestraining of billet on extrusion pressure at moderate temperature

Fig. 22 (top, right).—Load/penetration diagrams for coined 0.1 per cent carbon steel slugs showing the effect of strain heating on maximum punch pressure

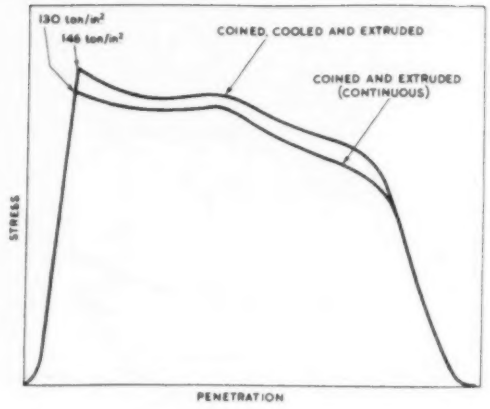
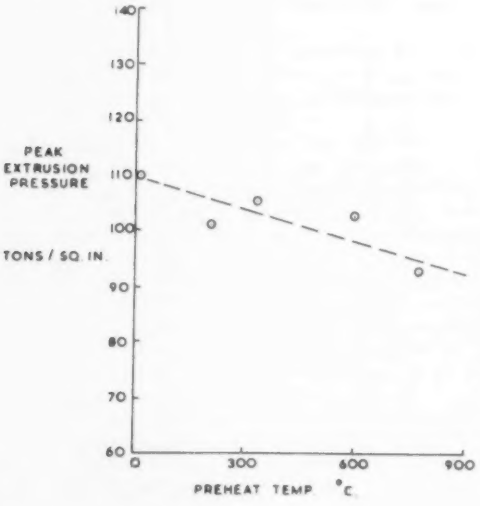


Fig. 23 (below).—Extrusion pressures for backward extrusion of 0·1 per cent carbon steel at elevated temperatures



The effect of billet temperature is now being investigated. The results in Table II illustrate the significant reductions in pressure required to extrude stainless steels by preheating the billets: low-carbon steels are affected by preheating to only a relatively small extent, as is shown in Fig. 23. (The results shown in Fig. 23 were obtained with a slightly lower reduction than those shown in the table).

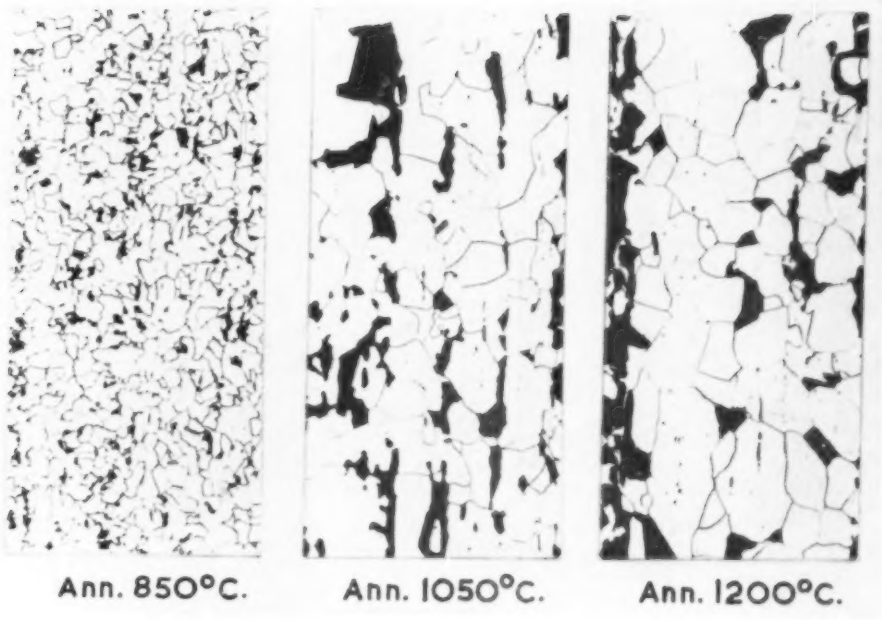
TABLE II

Billet Material		Punch pressure (tons per sq. in.)		Decrease in punch pressure with heated billets (per cent)
		Billets at room temp.	Billets heated to 600° C.	
Carbon Steel	0.1 per cent C	133	118	13
	0.3 per cent C	165	140	15
Stainless Steel	En 56D	191	110	42
	En 58D	198	119	40
	En 58A	227	118	48

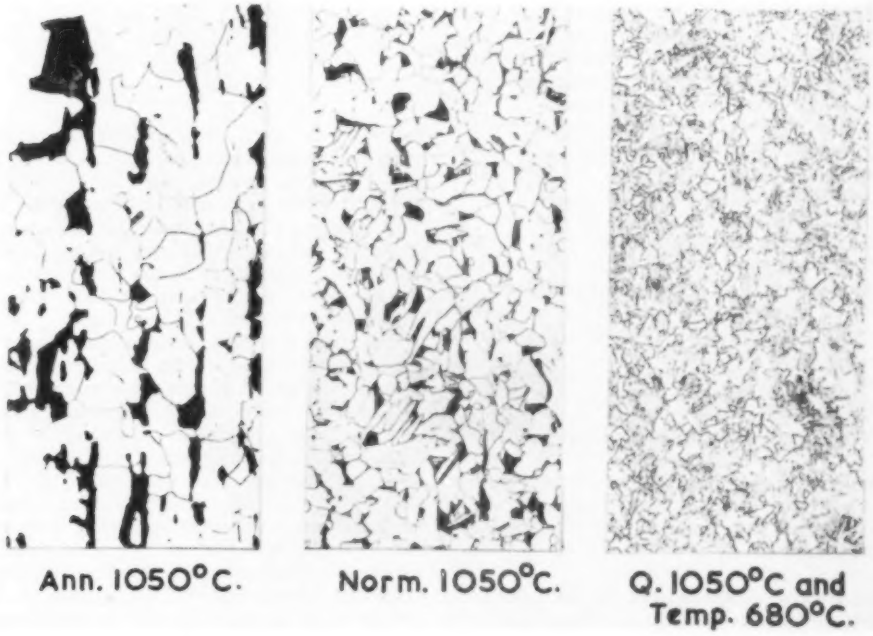
The very high loads associated with the cold extrusion of steel makes it desirable that the material from which the slugs are made should have the best possible structure to facilitate plastic flow.

PERA therefore undertook experiments to find the effect on the extrusion forces of different heat-treatments applied to the slug material.

A number of carbon steels were given heat-treatments including annealing, normalizing and water-quenching and tempering at various temperatures the latter treatment giving a spheroidized structure. Ferritic grain sizes of A.S.T.M. No. 7 for treatment at 850° C. to A.S.T.M. No. 3-4 for



Figs. 24 (× 100) *(above) and* 25 (× 100) *(below).—Micrographs of* 0.1 *per cent carbon test material for cold extrusion*



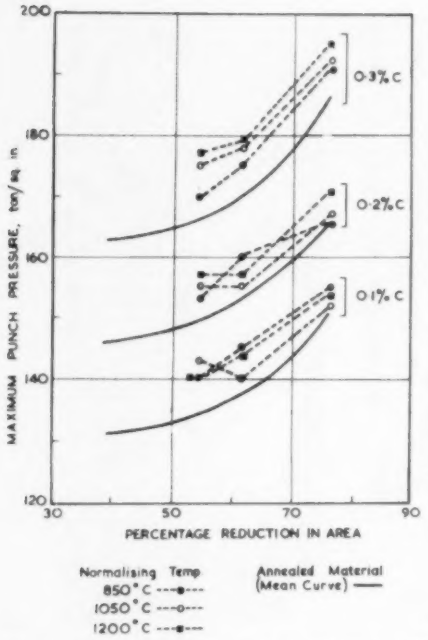
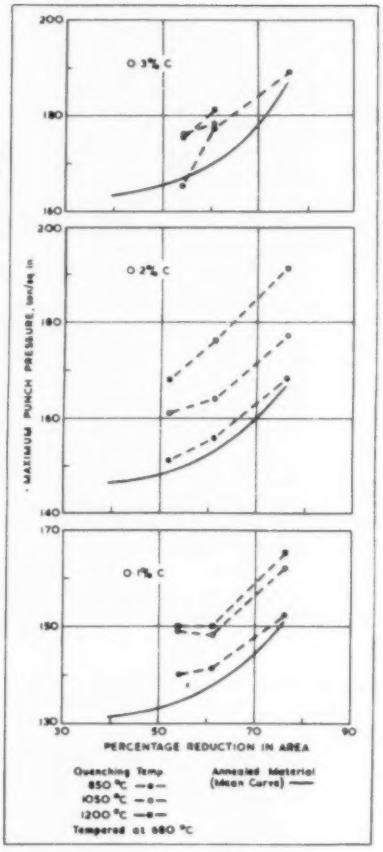


Fig. 26 (left).— Effect of normalizing treatment on punch pressures when backward extruding carbon steels

Fig. 27 (right).— Maximum punch pressures for quenched and tempered low-carbon steels



treatment at 1200° C. were achieved. Typical structures for 0.1 per cent carbon steel after heat-treatment are shown in Figs. 24 and 25.

Extrusion tests on these materials in the different conditions produced by the heat-treatments indicated that a full anneal gave the lowest pressures, with little variations due to annealing temperature. Fig. 26 shows that the normalizing treatments gave pressures higher by about 3 to 5 per cent.

As would be expected, the pressure for the quenched and tempered materials were, however, significantly higher, particularly at the higher quenching temperatures (Fig. 27).

It was found that the pressures for the as-received hot-rolled material were similar to those for the same materials normalized at 1200° C. some 5 per cent higher than for the fully annealed slugs.

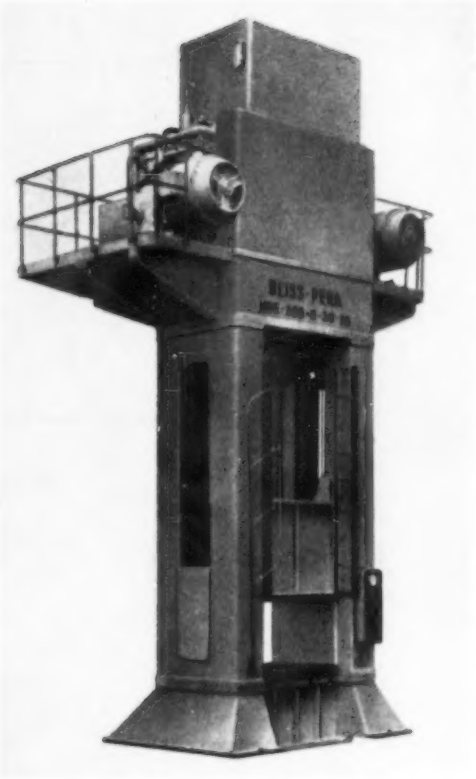
Thus in many applications where the punch pressures can be kept within reasonable values use of the hot-rolled material without heat-treatment, or given the relatively cheap normalizing treatment may be quite satisfactory.

Lubrication of Billets and Slugs for Cold Extrusion

Conditions during cold extrusion of steel are much more arduous than those for extrusion of the soft non-ferrous metals and it is usual practice to apply a phosphate coating to the slug material which is then given additional lubricant.

It is not fully understood why the zinc-phosphate lubricant system is so effective in assisting cold extrusion of steel, although studies of the undeformed coatings and observations on the "glass-like" coatings present after deformation have resulted in numerous explanations of the process. For example, the phosphate coat has a low shear strength and may thus act as an anti-friction substance : lubricant is thought to be absorbed into the pores of the crystalline coating, and also to adhere to the surface of the coating.

Investigations have been carried out into the effect of various phosphate coatings on extrusion forces. Variations in phosphate coatings from 0.7 to 8.4 gm. per sq. ft. were found to have little effect on extrusion pressures. Phosphating tests on steels with carbon contents of 0.1 per cent, 0.2 per cent and 0.3 per cent annealed at 850° C. and 1200° C. to produce different steel grain-sizes, indicated little variation in coating weights with these variables. These tests used a standard pickling and phosphating treatment. Attempts to vary the crystal size for any particular coating weight revealed that, in general, treatments resulting



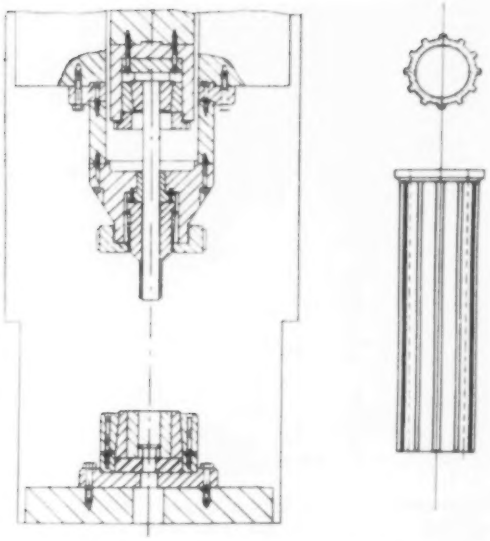


Fig. 28 (left).—New type of double-action hydraulic extrusion press

Fig. 29.—Typical arrangements of tooling for double-action extrusion press. (a) (top, right) Forward extrusion; (b) (bottom, left) Backward extrusion; (c) (bottom, right) Backward extrusion of flanged component

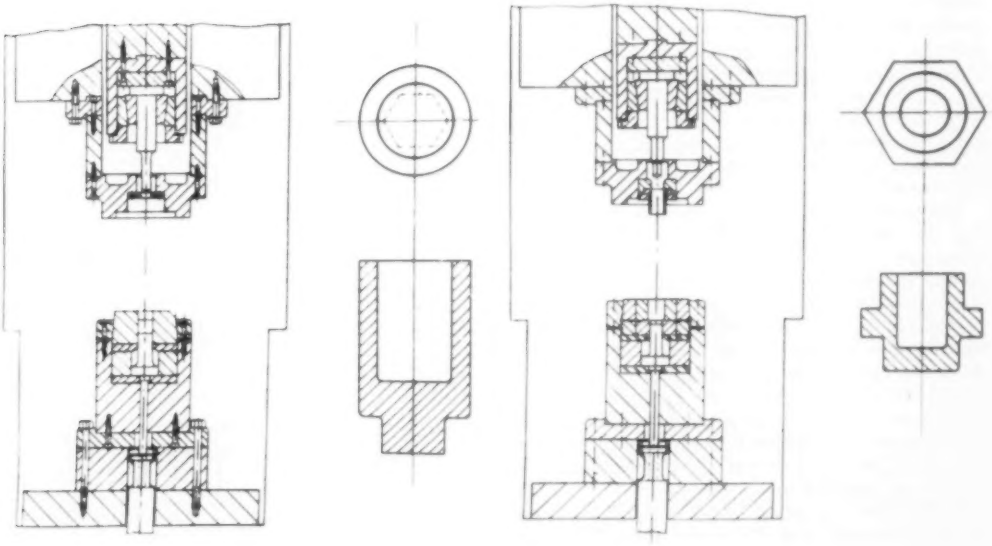


Fig. 30 (left).—Safety guards fitted to extrusion press

Fig. 31 (a) and (b) (below).—Design of component to facilitate extrusion

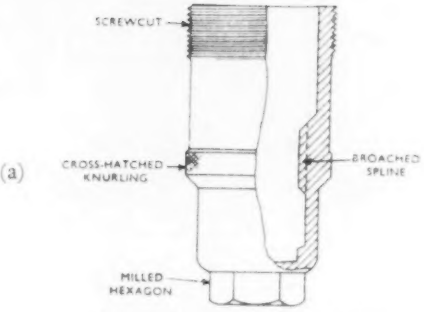
in increased crystal sizes also gave higher coating weights. These tests did illustrate the necessity of obtaining complete coverage by the coating in order to avoid localized welding or "pick-up" on the tools and severe scoring on the component.

Presses for Extrusion

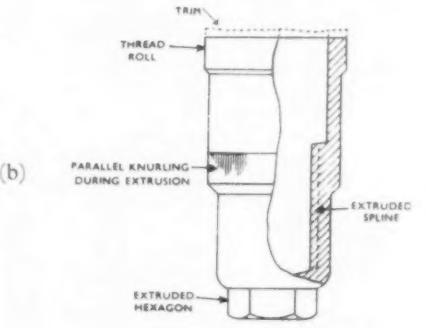
Considerable controversy exists regarding the relative merits of mechanical and hydraulic presses. For example, the uniform pressing speed of the hydraulic press is sometimes thought to be an advantage over the simple harmonic motion of a crank press. It is also argued that tool setting is less hazardous on a hydraulic press than with a mechanical press. On the other hand, mechanical presses are usually more suitable for incorporating mechanized slug feeding and ejection arrangements and are generally thought to be cheaper than hydraulic presses, at least in the smaller sizes. Very largely, however, the choice of any particular type of press is usually governed by personal preference and both hydraulic and mechanical presses have been used very successfully for cold extrusion of most metals.

One requirement that is common to both types is that the press should be sufficiently robust to withstand the severe forces involved during extrusion which are, in fact, many times higher than in other more conventional pressworking operations. The press should be designed to take a concentrated load on a small bed area, slideways should be generously proportioned, and the press should be able to deliver the full rated capacity throughout at least the last 20 per cent of the stroke. Some means of underneath ejection is required and the power for this is sometimes rated at one-fifth of the press capacity.

E. W. Bliss in co-operation with PERA have recently designed and developed a novel double-



Component as produced by machining



Redesigned for impact extrusion

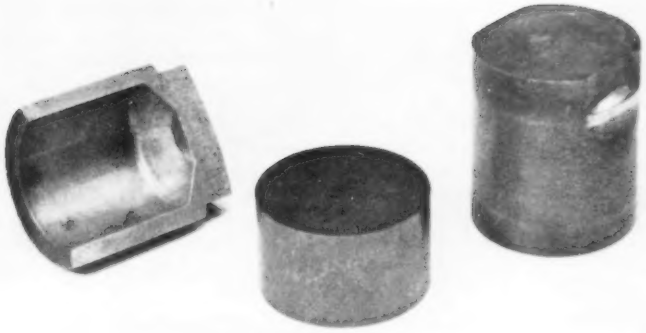


Fig. 32 (left).—Cold-extruded steel cap nut

Fig. 35 (bottom, right).—Steel cylinder

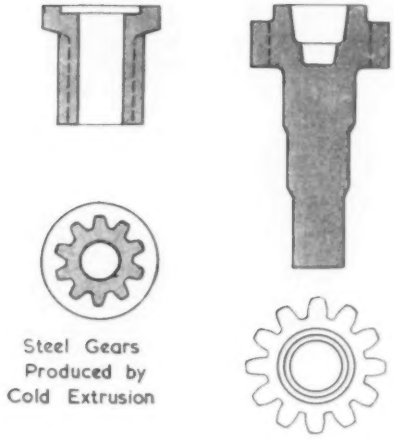
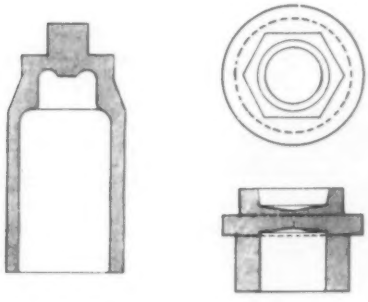
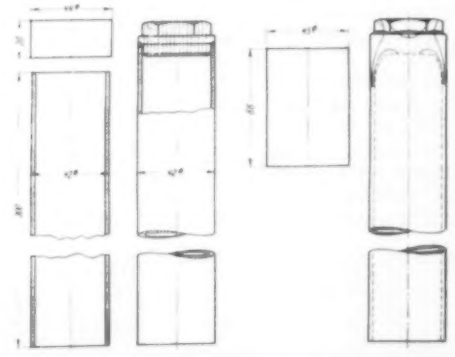


Fig. 33 (above).—Cold-extruded steel gears(*)

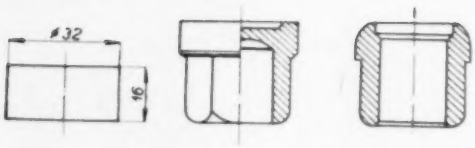
action extrusion press, shown in Fig. 28, which has a number of patented and unconventional features. The first Bliss-PERA press of 500-tons capacity is nearing completion and will be installed in the PERA laboratories by the end of 1960. The press has inner and outer rams either of which can act as the primary ram, depending on whether forward or backward extrusion is required. Typical arrangements of tooling in a press of this type are shown in Fig. 29. For a forward-extrusion operation (Fig. 29 (a)), the two slides descend at fast approach speed, automatically slowing down as the extrusion punch contacts the work. The inner slide continues to insert the mandrel or pilot and then both slides continue together to extrude the component. At a predetermined adjustable position the inner slide reverses, the extrusion punch meanwhile holding the component firmly in the die and finally the outer slide returns with the extrusion punch and the bottom ejector lifts the component out of the die.

Fig. 34 (below).—Typical cold-extruded steel components(*)





	WELDED ASSEMBLY	COLD EXTRUSION
Material	1.92 lbs.	1.77 lbs.
Time	15.9 mins.	1.94 mins.
Total Cost	4/7	1/10½



ORIGINAL SEQUENCE OF OPERATIONS	IMPROVED SEQUENCE OF OPERATIONS
Cut off	Cut off
Hot forge	Cold extrude
Remove Flash	Pierce end
Turn end	Turn end
Drill and Tap	Tap
Material Utilisation 40%	Material Utilisation 70%

Fig. 36 (above).—Comparison of methods of producing wheel nut

Fig. 37 (right).—Steel cap nut (long) operation sequence

which will enable many extrusion operations to be performed which would not be feasible on conventional presses without elaborate tooling arrangements and stripping devices.

Another important requirement on extrusion presses is that some provision should be made for protecting the operator in the case of tool failure. One satisfactory system is to fit plate steel guards to cover the front and rear openings of the press, as shown in Fig. 30. In some instances, however, it is possible to incorporate a shroud on the extrusion tooling which performs the same function as an external steel guard.

Component Design

A good idea of the scope of the cold-extrusion process can be given by considering some of the various design features that are applicable.

Many variations in base shape are possible and the end of the component can be either square, conical or hemispherical. Projections or depressions may be provided on both sides of the base, but the arrangement of these should be as symmetrical as possible to avoid unbalanced loading of the tools.

The base thickness is solely governed by the press setting and is therefore independent of the wall thickness. There is, however, a danger of cracking occurring in very thin bases and for this reason it is not wise to attempt a base thickness smaller than the wall thickness.

With both backward and forward extrusion, non-circular as well as circular sections can be produced; shallow external and internal axial ribs

In a typical backward operation (Fig. 29 (b)), the extrusion punch is fitted to the inner slide, the outer slide carries a punch guide and is used to hold the component in the die while the punch is stripped out before ejection. In another arrangement of tooling (Fig. 29 (c)), backward-extrusion punches can be mounted on both slides and a component with a flange part way along the walls can then be produced in one operation.

The motion of this press, together with the associated press control circuit, thus provides for a very wide variety of forward or backward extrusions or a combination of both, and results in a press

Fig. 38.—Steel cap nut (short) operation sequence

are also possible. Asymmetrical sections are not impossible to produce but they cause uneven tool loading and may result in poor tool life. If a component with one longitudinal rib is required it is preferable, for example, to introduce another diametrically opposite rib even if this has no functional purpose.

Parts with two different diameters can be produced by forward and backward extrusion in one operation. The smallest diameter is usually forward extruded. Parts with more than two diameters usually require more than one operation.

Solid parts, such as shafts, can be produced by forward extrusion, several operations sometimes being necessary for multi-diameter components. Sections can be other than circular and splines, for example, can be provided. The production of parts requiring a taper is generally not feasible by cold extrusion alone. An exception is where a hollow part has a tapered section joining two sections of different diameter, when the tapered section will be produced in compression as the junction between a combined forward and backward extrusion.

Although the extrusion operation is very versatile, it cannot be over-stressed that not all components as initially designed may be suitable for extrusion and it may be necessary to alter the component design to facilitate extrusion. A typical example of this is shown in Fig. 31. Ideally, however, components should be designed initially with a knowledge of the potentialities of extrusion.

Applications

Typical cold-extruded components in steel are shown in Figs. 32 to 39.

In most applications, useful economic savings can be made, particularly in the case of extruded steel components where the saving in material compared with that required for machining operations is usually most notable. A typical example of the savings that can be made is given by the component shown in Fig. 35, which was originally made from precision tube with a separately machined end welded to it. The part was later produced as a backward extrusion with a considerable material saving and at a total cost of 41 per cent of the original method(7). The car wheel nut (Fig. 36), when extruded resulted in a material utilization of 70 per cent with a total material saving of 45 per cent(8). With larger quantity production, gains of this magnitude result in considerable savings in cost.

There is no doubt that cold extrusion is a most attractive operation with tremendous potentialities. It is not, however, a panacea for everything and each application has to be chosen carefully.

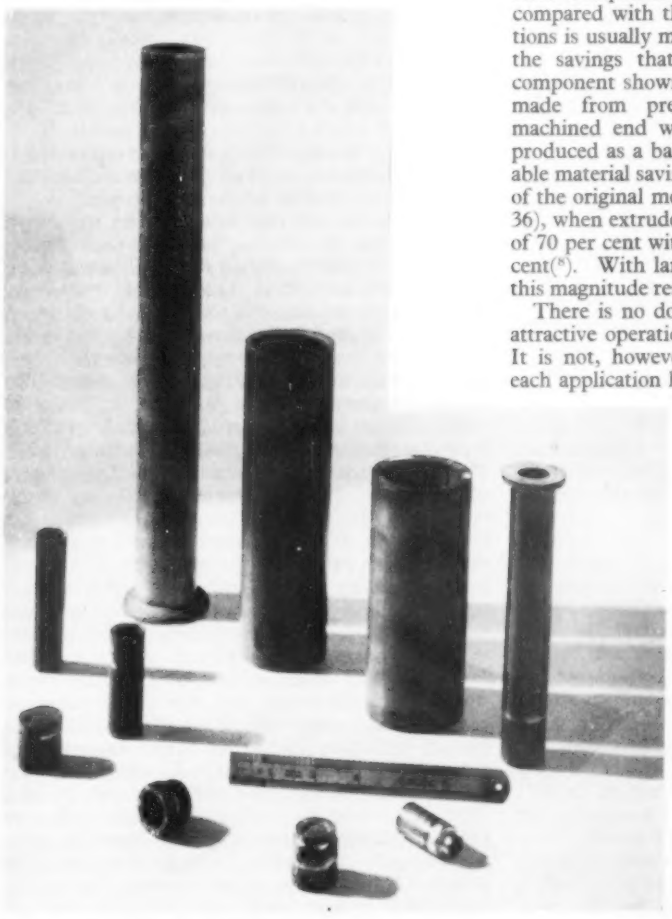


Fig. 39.—Selection of steel components extruded at P.E.R.A.

There are many problems associated with the use of cold extrusion and clearly, before embarking on the process, the question of whether or not extrusion is economically justified must be carefully considered. PERA has collaborated with a number of firms in developing the technique for the production of particular components. Not all, of course, have been successful, frequently because of the inadequacy of present tool materials, but in some cases due to the characteristics of work materials. This work is done as part of PERA's research and development service to industry, and enables companies to have all experimental work carried out and a pilot production run made before embarking on the necessary capital expenditure for producing cold extruded parts.

Acknowledgements

The authors wish to thank the Production Engineering Research Association for permission to use certain research results.

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DISCUSSION

Mr. DREWERY (English Steel Corporation), referring to Fig. 33 in the paper, said that he would like to make such a part 10 in. long with the smallest diameter about 1¼ in. He would like to ask Mr. Howard and the meeting generally in how many operations it was possible to do this. How were the parts kept straight in between interstage annealing, assuming that this was necessary? How were the gear teeth extruded sideways? How did the author think the cost of perhaps 500,000 of these would compare with the hot forging cost? Also what was the size of the press required to cater for the largest load, probably the sidewise extrusion of the teeth, and what was the hardest or toughest material from which it was possible to make such a part for use in the pinion drive of a motor-car?

Mr. HOWARD said that this was a formidable list of questions. Fig. 33 was an illustration taken from an American source and he had no direct figures on it. He had had something to do with a similar component to the fairly long one shown on the right-hand side of the diagram which had previously been made by hot forging. While the component had been successfully extruded, the economics finally turned out to be unfavourable mainly because the hot forging people, possibly as a result of the threat of competition, had improved their own forging enormously. Whereas originally there had been a promise of a saving of about £100,000 a year in material, the considerable improvement in the hot forging technique reduced the potential saving almost to nothing.

Punch Load

Mr. SPIKES (Joseph Lucas Ltd.) said that if PERA advised member firms to use punch loads or 150 tons per sq. in. they would be advising them wrongly. It was not possible to expect to get adequate life out of a tool under those conditions and Mr. Morgan, in his paper, confirmed this. Second, there was a great lack of information on the diagrams in the paper—in striking contrast to those in the N.E.L. paper. This made them fairly useless so far as drawing inferences from them were concerned, or indeed cross reading from one to the other.

Only one case had the length-to-diameter ratio of blank mentioned. As had been pointed out, this had a substantial effect on extrusion forces.

Mr. HOWARD said that in most cases the length and diameter of the slug had not been varied. PERA had been concerned not with duplicating the type of tests carried out at N.E.L. but rather with investigating some of the factors upon which industry required information. Most of these observations were made under production conditions, and some when extruding commercial component shapes.

He said that the recommendation made in PERA reports was that punch stresses should not exceed 150 tons per sq. in. and he did not think this figure was too high. He would refer Mr. Spikes to the remarks of Mr. Pugh and himself to the effect that it was very difficult to get a loading that was less than 135 tons per sq. in.

Mr. PUGH, also referring to punch stress, said that he had given figures about the extrusion pressure and had described the punch stress as being twice the value of the extrusion pressure which occurred at an extrusion ratio of 2. Fig. 12 of his paper showed that, for Armco iron, the punch stress, to produce a can, would be of the order of 120 tons per sq. in. For En2A the figure would be in excess of 160 tons per sq. in. He agreed that the figures would be slightly reduced for cans because they were based on rods. They would also be slightly reduced if the length-to-diameter ratios were short. These were the punch stresses, and if punches did not stand up to continuous operation, particularly in hard steel, it meant that it was not

possible to do a canning operation on the steel, and this was a limitation of the process.

Mr. SPIKES said that he quite agreed with everything that Mr. Pugh had said, but in his paper it was possible to deduce these corrections. Admittedly, some of his curves were of 1 in. radiuses, and some were for different materials, but enough information had been given to deduce what could and could not be made. This was what was important to industry.

Mr. PUGH said that Mr. Spikes seemed to be adverse to the figure of 150 tons per sq. in. Was there any information that a punch working at this level would have a limited life?

Average Stressing on Punch

Mr. MORGAN (R.O.F., Birtley) said that speaking in terms of an average stressing on the punch, it was really nothing like that at all. The photo-elastic stress diagrams showed that there was a marked stressing around the nose of the punch. He would think that the figure was far higher than 150 tons per sq. in.

It was very easy to be critical but he would like to sound a note of warning about some of the diagrams that were offered. In Fig. 2 the punch was shown as coming up against a backing plate. There was a large hole but the backing plate was very thin. It ought to be twice its indicated depth or there would be distortion. He had actually had a case of a thin backing plate coming up and causing distortion.

He would like to make a correction to Fig. 13 as he did not think that the component shown could be produced with the punch-nose indicated. The component would have a taper, and might even be distorted. The adjoining figure, which he had seen before, showed the punch being held by two rings. What was the reason for this? It merely seemed to introduce two sets of complications. Everyone knew the difficulty of making a taper to fit a taper. There was a tolerance on the taper, with the consequence that it would only fit on one diameter. Were the two rings there from mere cunning in order to make an external taper fit an internal taper by stressing one component with another? If not, it would be preferable to remove one set. The punch was guided by the die, but when the load was applied the die expanded and no longer guided the punch. If it was a long punch, it began to lose the guidage as soon as the load was put on.

Mr. HOWARD said that Fig. 2 was a drawing of a backward extrusion tool and dynamometer used for investigational work on backwork extrusion. Mr. Morgan was perfectly right in what he had said about the backing plate. The backing plate acted as a safety device when extremely high extrusion loads resulted. The plate was designed in such a way that the shank of the extrusion punch sheared a hole through it when a pre-determined load was exceeded, thus obviating damage to the tool assembly. The device worked very successfully but would not be incorporated in production tools.

He could not comment in detail about the tooling shown in Fig. 13 as this had been reproduced from a previously published source.

Mr. MORGAN said that the figure on the right-hand side of the page originally stemmed from a German publication.

Mr. MCKENZIE said that it had appeared in the paper by Fischer at the 1953 I.S.M.E. conference. He had thought that the ring was of soft material so that if there was any inaccuracy in the tapers between the two it would take up the soft materials.

Extruding Long Lengths

Mr. DREWERY (English Steel Corporation) said that since no one seemed willing to comment on Fig. 33 he could only assume that this part could be made economically only by hot forging, and that it had been a mistake to include it in a cold-forging paper. However, he would like to ask Mr. Howard about the tolerances in cold extrusion. Some interest had been shown in extruding long lengths of components such as solid gears, and Mr. Pugh, in his Fig. 9, had shown tolerances of the order of ten thousandths of an inch. He had always thought that one of the big advantages of cold extrusion was a very close control over tolerances, and if it was possible to extrude gears, even of small diameter, to closer tolerances than one ten thousandth would it be an economic proposition?

Mr. HOWARD said that he had not made any detailed study of tolerances for the cold extrusion of steel. However, some limited observations had been made on some of the specific components with which he had been concerned but Mr. Griffiths had made the point quite well in his paper that while it was possible to get very good tolerances on cold extrusion sometimes it might be quite uneconomic to do so. It might mean considerable stressing of tools and chasing the last ounce of material too far, in which case one should consider cold extrusion as a means of getting nearly to the final shape, and then machining.

Mr. MORGAN said that an extruded component came out to a diameter and would be reproducible to that diameter every time while the die remained satisfactory, and the punch also. If the diameter did not satisfy, the die was adjusted and another diameter obtained; eventually one that was suitable was obtained. Without this, cold extrusion was not a suitable process because the hot forgers and the warm forgers would produce to very close tolerances indeed.

His own organization had been successful in making their first gear blank. However, it had been necessary to make two or three dies and in one case it had been necessary to put an increased

load on it to shrink it to the effective diameter. This could be done fairly easily with the right machine. Gears could be made to an effective diameter: it was not necessary to machine them. If absolute accuracy were wanted in all cases, it might be necessary to include a shaving operation. This might be too expensive for normal commercial work, but it would not be needed.

Mr. HOWARD said that he had not meant to give the impression that it was not possible to obtain an accurate component by cold extrusion. It was difficult to generalize, but surely, in the end, it was a question of economics. For example, the ultimate accuracy might be obtained at the expense of tool life, and it might thus be cheaper to finish by machining. Each part had to be considered on its merits. Some of the components shown in the later pages of his paper could be produced quite satisfactorily by cold extrusion. The multi-stage component shown in Fig. 34 had been one in which the bore had not needed additional operations, nor had the outside. It had been made to within 0.001 in., but in other cases it had been quite impracticable to take components to final dimensional tolerances without some machining.

Mr. MCKENZIE said that he wished to refer to Mr. Drewery's alarm at the variation in tolerance in the rods shown in Fig. 9. First, the die entry had been sharp-edged, and there was a tendency for the tolerance of the product to vary due to this factor over the length of the extrusion. The first part was near die size and the last somewhat further away. He would hazard a guess and say that if about 120 deg. or 130 deg. cone angle was used the tolerances would be much nearer die size and the product would be more uniform over the length: each product made would be the same size. The ejection loads for various die angles were available. N.E.L. also had figures on the dimensions of rods extruded from these various dies. It had been found that, with a 60-deg., 50-deg., and 40-deg. cone angle, the diameter of the rod was about 0.0015 in. over the size of the die.

Internal Stress

Mr. GRASSON (English Steel Corporation) said that no one had mentioned the general level of internal stress of forged components. It had been suggested that it would be possible to use the enhanced properties of cold forging, increased yield stress, yield ratio, etc. Would teeth profile etc. distort too greatly owing to residual stresses? Had the temperatures used for annealing carbon steels gone so high as to coarsen the grain? This would not be practicable with the low-alloy hardening steels, which in most cases were grain-controlled anyway.

Mr. ANGUS replied that the temperatures had been chosen to coarsen the grain. The intention had been to show what difference the grain-size would make to the extrusion loads, and in order that this should be on the same steel the grain had been coarsened by increasing the temperature. The unfortunate part about that was that the temperature effect as well had to be taken into account, but it was the only way in which that could usefully be done.

Mr. N. D. G. MOUNTFORD (Rolls Royce Ltd.) said that on page 12 of the paper the increased billet temperature had been given, as well as its effect on the reduction of punch pressure. It seemed that the authors must have, to some extent, solved the lubrication problem.

Mr. DENNISON replied that this was not yet the case. In these particular samples, which were of a preliminary nature, they had used graphite as a lubricant. Powdered graphite had been applied to the slugs and to the inside of the die and to the punch. The actual lubrication of heated slugs in practice had yet to be decided.

Effect of Heating on Punches

Mr. L. R. HAWTIN (I.C.I. Metals Division), referring to warm extrusion, said that the figures given showed reduction in punch pressure as a result of this method, but at 600° C. the tools were going to be very much hotter than room temperature. He would expect that the maximum pressure that could be applied to such tools would be more restricted. Mr. Morgan had referred to warm extrusion also. Any further work in this direction should be accompanied by a study of the effect on tools; it might be that the disadvantage of tool heating more than offset the advantage of reduced heating anyway. He could not understand why, in Fig. 20, there was a difference between the curve referring to annealed material and that referring to 0 per cent prestrain.

Mr. HOWARD said that he agreed about the effect of heating on punches. He and his colleagues were very concerned about it. It was quite recent work and had to be taken much further. It could well have a serious effect on tools.

Mr. DENNISON said that the prestrain referred to had been applied to as-received material. It was not intended that the 0 per cent prestrain should be considered as annealed material. The latter was only given as an indication of the loads which would obtain when the material was used in that condition. In fact, the curves showed that when the as-received material had been prestrained by 20 per cent and the sub-critically annealed, the punch pressures were brought down to within 0.5 per cent of those for annealed material.

Mr. RADFORD (Rolls Royce Ltd.) said that he wished to refer to the preparation of the slug or billet insofar as material utilization was concerned. What had the authors found in their investigations about the squareness of the slug end? Did it

(*Continued in page* 425)

Some Investigations into the Cold Extrusion of Steel.

(*Continued from page* 424)

matter what type of finish was on the cut-off region?

In some of the diagrams interstage extrusions from a billet with a cone angle had been used. How much importance was to be attached to the relationship between the cone angle and the use of a large or small radius to the stem?

Was the 1,000-ton crank press fitted with a variable-speed motor and, if so, what was its maximum stroking range?

Mr. HOWARD said that the press was not fitted with a variable-speed motor. It was geared to give 13 strokes per min. with a ram travel of 26 in.

Preparation of Slugs

The preparation of the slugs was a matter of some concern at the moment. He had been looking at this in various ways to see, first, how they should improve the condition obtainable by shearing or cropping, applying their experience in hole punching operations. First results of precision shearing had been promising but a great deal of further work was required.

Recently they had been producing backward-extruded cans by cropping the slug from ½-in. dia. wire, then coining and extruding. They had gone straight from the fairly rough sheared condition into the coining stage and straight from that into extrusion. The resulting finish was certainly inferior to what had been obtained previously from machined and lubricated slugs, but it was quite encouraging and they were continuing the work.

He said that most of the work they had done on forward extrusion had been with straight cone angles. The particular sequence referred to had been devised for a commercial development and there was as yet insufficient experience with multi-stage processes to draw any conclusions on billet profiles.

Mr. J. D. MANTLE (Ministry of Aviation) said that no-one had mentioned scrap rates. If cold-extrusion equipment was installed one would want to use it and there might be cases where the cost was marginal and scrap rates could put it out of court.

He was rather concerned at the attitude that if one did not get what one wanted recourse should be had to machining. As he had been concerned in the main with machining this rather frightened him. Had the author's colleagues any experience of how metal machined after the process was carried out? Did it machine easily? The worthy effort of the hot forgers to produce something nearer size might be commendable from the point of view of material utilization but it would be very nasty to machine if one had only 0.015 or 0.010 in. left. It would be all skin. One would be far better off with the original rough forging.

Mr. HOWARD replied that his organization had no direct experience of scrap rates in actual production. Steel did machine fairly easily after extrusion, as far as one could gather. It was true that a hot forging with reduced machining allowance might mean that machining would be more difficult but he would assure Mr. Mantle that this was usually considered of secondary importance when a substantial material saving was being made.

The CHAIRMAN said that he felt the discussion had been very worth while. The work recorded in Fig. 15, on the effect of sub-zero treatment, was a very important advance, because this was decomposing the retained austenite in the 2 per cent carbon 13 per cent chromium steel, and if those who overtaxed their punches cared to begin with a vacuum annealed treatment and then perhaps put on a vacuum temper and sub-zero treatment as well, they would obtain good performance. He felt that the authors from N.E.L. and PERA would feel that the discussion had been their reward for their efforts.

WORLD'S WIDEST ALUMINIUM ROLLING MILL TO BE INSTALLED AT FALKIRK

Expansion Programme Announced by British Aluminium Co. Ltd.

THE British Aluminium Co. Ltd. will spend over £10 million on new equipment as an extension to the Falkirk rolling mills in Scotland. The first stage comprises a hot mill approximately 172 in. wide which will treble Falkirk's ultimate capacity to 150,000 tons a year. Work will begin immediately and cold rolling and finishing capacity will be increased to absorb the hot-rolling capacity over a succeeding period as the growing market for aluminium warrants. This will be the widest aluminium rolling mill in the world.

The British Aluminium Co. Ltd. envisages that aluminium usage will grow at at least twice the national average rate of industrial growth and in particular for markets such as packaging, transport, building and household appliances the rate should be even higher. British Aluminium Co. Ltd. has a large and rapidly expanding export business and the company says that these additional facilities will enable it to remain fully competitive in world markets.

load on it to shrink it to the effective diameter. This could be done fairly easily with the right machine. Gears could be made to an effective diameter: it was not necessary to machine them. If absolute accuracy were wanted in all cases, it might be necessary to include a shaving operation. This might be too expensive for normal commercial work, but it would not be needed.

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Mr. DENNISON replied that this was not yet the case. In these particular samples, which were of a preliminary nature, they had used graphite as a lubricant. Powdered graphite had been applied to the slugs and to the inside of the die and to the punch. The actual lubrication of heated slugs in practice had yet to be decided.

Effect of Heating on Punches

Mr. L. R. HAWTIN (I.C.I. Metals Division), referring to warm extrusion, said that the figures given showed reduction in punch pressure as a result of this method, but at 600° C. the tools were going to be very much hotter than room temperature. He would expect that the maximum pressure that could be applied to such tools would be more restricted. Mr. Morgan had referred to warm extrusion also. Any further work in this direction should be accompanied by a study of the effect on tools; it might be that the disadvantage of tool heating more than offset the advantage of reduced heating anyway. He could not understand why, in Fig. 20, there was a difference between the curve referring to annealed material and that referring to 0 per cent prestrain.

Mr. HOWARD said that he agreed about the effect of heating on punches. He and his colleagues were very concerned about it. It was quite recent work and had to be taken much further. It could well have a serious effect on tools.

Mr. DENNISON said that the prestrain referred to had been applied to as-received material. It was not intended that the 0 per cent prestrain should be considered as annealed material. The latter was only given as an indication of the loads which would obtain when the material was used in that condition. In fact, the curves showed that when the as-received material had been prestrained by 20 per cent and the sub-critically annealed, the punch pressures were brought down to within 0.5 per cent of those for annealed material.

Mr. RADFORD (Rolls Royce Ltd.) said that he wished to refer to the preparation of the slug or billet insofar as material utilization was concerned. What had the authors found in their investigations about the squareness of the slug end? Did it

(*Continued in page* 425)

Some Investigations into the Cold Extrusion of Steel.

(*Continued from page* 424)

matter what type of finish was on the cut-off region?

In some of the diagrams interstage extrusions from a billet with a cone angle had been used. How much importance was to be attached to the relationship between the cone angle and the use of a large or small radius to the stem?

Was the 1,000-ton crank press fitted with a variable-speed motor and, if so, what was its maximum stroking range?

Mr. HOWARD said that the press was not fitted with a variable-speed motor. It was geared to give 13 strokes per min. with a ram travel of 26 in.

Preparation of Slugs

The preparation of the slugs was a matter of some concern at the moment. He had been looking at this in various ways to see, first, how they should improve the condition obtainable by shearing or cropping, applying their experience in hole punching operations. First results of precision shearing had been promising but a great deal of further work was required.

Recently they had been producing backward-extruded cans by cropping the slug from $\frac{1}{2}$-in. dia. wire, then coining and extruding. They had gone straight from the fairly rough sheared condition into the coining stage and straight from that into extrusion. The resulting finish was certainly inferior to what had been obtained previously from machined and lubricated slugs, but it was quite encouraging and they were continuing the work.

He said that most of the work they had done on forward extrusion had been with straight cone angles. The particular sequence referred to had been devised for a commercial development and there was as yet insufficient experience with multi-stage processes to draw any conclusions on billet profiles.

Mr. J. D. MANTLE (Ministry of Aviation) said that no-one had mentioned scrap rates. If cold-extrusion equipment was installed one would want to use it and there might be cases where the cost was marginal and scrap rates could put it out of court.

He was rather concerned at the attitude that if one did not get what one wanted recourse should be had to machining. As he had been concerned in the main with machining this rather frightened him. Had the author's colleagues any experience of how metal machined after the process was carried out? Did it machine easily? The worthy effort of the hot forgers to produce something nearer size might be commendable from the point of view of material utilization but it would be very nasty to machine if one had only 0.015 or 0.010 in. left. It would be all skin. One would be far better off with the original rough forging.

Mr. HOWARD replied that his organization had no direct experience of scrap rates in actual production. Steel did machine fairly easily after extrusion, as far as one could gather. It was true that a hot forging with reduced machining allowance might mean that machining would be more difficult but he would assure Mr. Mantle that this was usually considered of secondary importance when a substantial material saving was being made.

The CHAIRMAN said that he felt the discussion had been very worth while. The work recorded in Fig. 15, on the effect of sub-zero treatment, was a very important advance, because this was decomposing the retained austenite in the 2 per cent carbon 13 per cent chromium steel, and if those who overtaxed their punches cared to begin with a vacuum annealed treatment and then perhaps put on a vacuum temper and sub-zero treatment as well, they would obtain good performance. He felt that the authors from N.E.L. and PERA would feel that the discussion had been their reward for their efforts.

WORLD'S WIDEST ALUMINIUM ROLLING MILL TO BE INSTALLED AT FALKIRK

Expansion Programme Announced by British Aluminium Co. Ltd.

THE British Aluminium Co. Ltd. will spend over £10 million on new equipment as an extension to the Falkirk rolling mills in Scotland. The first stage comprises a hot mill approximately 172 in. wide which will treble Falkirk's ultimate capacity to 150,000 tons a year. Work will begin immediately and cold rolling and finishing capacity will be increased to absorb the hot-rolling capacity over a succeeding period as the growing market for aluminium warrants. This will be the widest aluminium rolling mill in the world.

The British Aluminium Co. Ltd. envisages that aluminium usage will grow at at least twice the national average rate of industrial growth and in particular for markets such as packaging, transport, building and household appliances the rate should be even higher. British Aluminium Co. Ltd. has a large and rapidly expanding export business and the company says that these additional facilities will enable it to remain fully competitive in world markets.

PRODUCTION OF ELECTRIC WATER HEATERS USING "STELVETITE"

Some Details of Practice at the Salisbury Works of AIDAS ELECTRIC LTD.

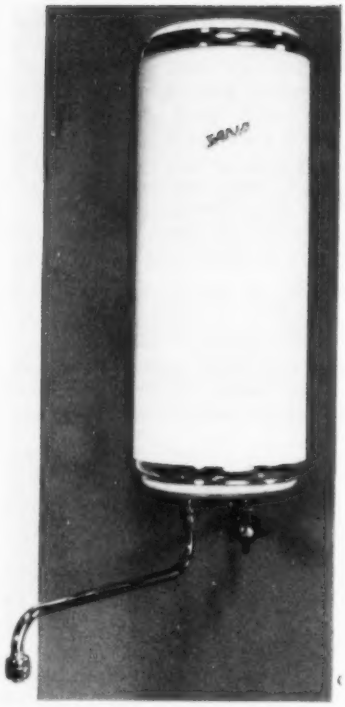


Fig. 1.—The Sadia "Two-plus" electric water heater

TO meet the growing home and overseas demand for their Sadia water heaters and other electric water heating appliances, Aidas Electric Ltd. have opened a new factory at Castle Road, Salisbury. This will manufacture the Sadia "Two-plus", and eventually another popular sink model, the Sadia "Select". It is also producing immersion heaters and thermostats.

Production plans are for 1,350 water heaters, 5,500 immersion heaters and 10,500 thermostats each week. To achieve these output figures, employment will be found for 300 people, mainly women, who are being recruited entirely from local rural districts. About half this number is engaged at present. Few have had any previous industrial experience, but they have responded readily to training and settled down extremely quickly and satisfactorily to the light-assembly work involved, the company states.

Sadia Works, Salisbury, which has a total floor area of 60,000 sq. ft. was originally built in 1943 for wartime Spitfire production. It continued to be used for the manufacture of aircraft components until last year. In adapting the factory to its present role the company have carried out a number of structural alterations and an extensive re-wiring and re-decorating programme. New plant and equipment worth £35,000 has been installed. First-class canteen facilities are provided.

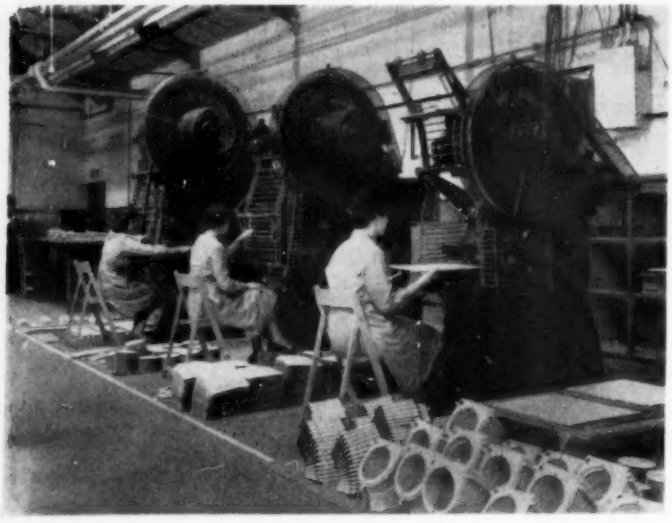


Fig. 2.—Top and bottom plates of the heater casing are in "Stelvetite." Three Bentley presses are used for these operations

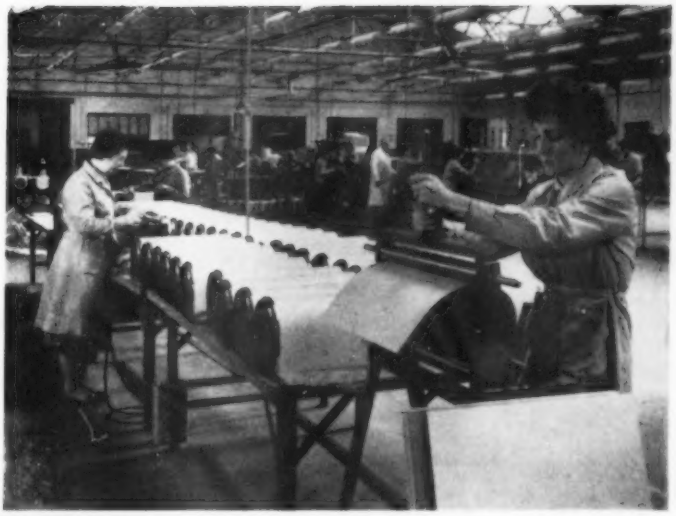


Fig. 3 (right).—The "Stelvetite" outer casing of the heater is here being formed to shape on a simple hand roller mechanism

Fig. 4 (below).—The copper water container for the heater has all seams silver soldered

The move to Salisbury is a result of consistent expansion by Aidas Electric, which has its headquarters in Northolt, Greenford, Middlesex, and subsidiary companies in South Africa and the Netherlands. The company was founded in 1932 by the late Mr. L. P. Haussauer, who after several years' importing water heaters from Switzerland, began to make the first British Sadia models in a small factory in Willesden, London.

At Salisbury the Sadia "Twoplus" is being manufactured with an outer casing of Stelvetite plastic-coated steel, in contrast to the glossy enamelled finish of the original version, which continues in production at the Sadia Works, Northolt. Initial output of the Stelvetite "Twoplus" is 250 a week, which will be steadily built up to 1,350 a week. For the time being, the new heaters are being made in white only, but a range of colours is shortly to be introduced.

Apart from improving the appearance and durability of the heaters, the use of Stelvetite has the advantage of eliminating a number of manufacturing processes, thereby saving in space and labour. It does, however, call for different techniques, a greater emphasis on factory-floor cleanliness, and care in press-tool design.

Three Bentley presses of 80-, 50- and 30-tons capacity respectively are used for producing the top and bottom plates for the outer casing. The bottom plate has a circular aperture pressed out of it to allow access to the underside of the main body into which the thermostat, heater, wiring, etc., are fitted. This aperture is covered by two semi-circular cover plates, also of Stelvetite, attached to the bottom plate by knurled screws, and through which holes are pierced to take the water inlet and outlet pipes and the grommet for the electric mains feed wires. These top and bottom plates are now made with the lugs which are used to attach the plates to the outer casing, as integral parts; formerly the lugs were attached as separate components. Setting of the lugs is effected in the 30-ton press.

The main outer casing is first notched and return edges made on an F. J. Edwards press brake, after which a simple hand roller mechanism forms the sheet to the required shape of the outer casing. A simple hand-operated punch makes the holes in the main casing sheet required for attaching the company's brand name, after which the cut edges of the sheet are sealed with a plastic compound.

Fig. 5.—Hot-dip tinning the water container

The main body of the heater is built up from a rolled cylinder produced from copper sheet, onto which spun ends are silver soldered. The main body has a longitudinal lock seam which is also silver soldered. On to the bottom end of the body a brass base plate is attached, also by silver soldering; this is pre-drilled to accommodate a copper thermostat tube, the heater tube, and the baffle dome to the cold water inlet, all of which are first secured by expanding. The whole assembly is pressure tested before hot-dip tinning which is effected by hand. The bodies are pickled, washed, fluxed and tinned by rolling by hand in a shallow bath of molten tin. The use of a shallow bath in conjunction with "rolling" the body in the tin has been found to be quicker and less wasteful of tin than using complete immersion in a deep bath.

After tinning, the bodies are wiped with cotton wool impregnated with NH_4Cl to prevent "yellowing" of the tin, after which they are pressure tested at a hydraulic pressure more than double that required in service. In connexion with the pressure testing the spun top of the body is made with a "flat" on it; after pressure testing the top becomes a "dome" and gives a clear indication that pressure testing has been carried out.

Subsequently chromium-plated outlet and inlet extensions and an independently-tinned flow tube are added.

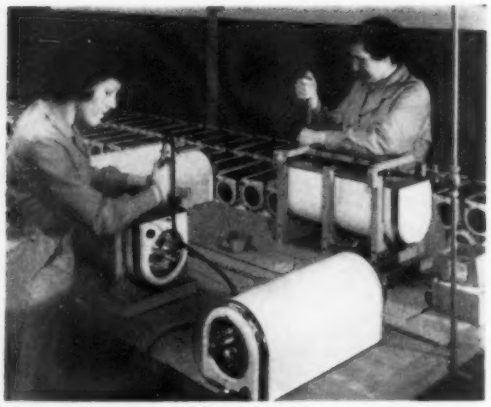


Fig. 6.—One of the final operations on the heater is to assemble the back plate of the heater; this is in Zintec sheet

Assembly of the heater involves the attachment of twin chromium plated bands and the top and bottom plates, all of which are held by self-tapping screws driven through the lugs on the top and bottom plates, the casing and into the decorative bands. Desoutter air tools are used for this operation. The casing is lined with Fibreglass blanket, the heater body placed in this and located in position by a cork block at the top of the container; a Fibreglass cover completes the insulation. The flat back of the heater is of Zintec sheet with a rubber moulding round the edge which fits into the rear aperture of the outer casing, making an effective seal with the wall when the heater is installed.

An element, wound on Steatite formers and rated at 1,000 W. is added, finally the complete heater is tested to 1,500 volts before despatch.

It is estimated that the use of Stelvetite for the outer casing of the sink water heater has given a saving of about 17½ per cent in capital costs at the works; in addition, the company have been able to start production several months earlier than would otherwise have been possible.

Other products being manufactured at Salisbury include a range of electric immersion heaters and thermostats (Aidastats).

The thermostats operate on the usual principle of an Invar-type alloy rod within a brass tube to one end of which the rod is firmly attached. Some of the components for the thermostats are produced on a Humphris 10-ton "Pressmaster" press fitted with a roll feed. The main contact spring is a typical example. This component is in beryllium-copper strip; the tools are of the follow-on type and an electric muffle is provided at the side of the

(*Continued in page* 441)

Producing a SPECIAL OIL DRAIN RING from Sheet

By "TARENTFORD"

THE article shown in Fig. 1 is circular and all the holes with the exception of a slot pierced through the side wall, and the single aperture are spaced radially from the centre-point—a feature that simplified machining. The design and manufacture of a set of tools for producing these details appeared, at first a costly business, but further examination of the problem suggested that a more economic approach was possible. A detailed view of this equipment reveals that one important factor exercises a strong influence on the design, and this, coupled with the necessity of accurately spacing the three centre holes with the side faces of the radial aperture, vindicates the apparently expensive design of the various tools.

Reverse drawing of the type shown in the figure is severe and there is little hope of achieving a satisfactory component at the blank and form stage without a preliminary draw to semi-finish the profile, and though the tool for such an operation is expensive to make, and the time for the process is obviously an added expense, subsequent drawing to produce the prominent U-shape is easily accomplished without fear that the flanges will split. Piercing the three holes in relation to the sides of this aperture was carried out at a single press stroke in order to ensure that the workpieces were within the specified tolerances.

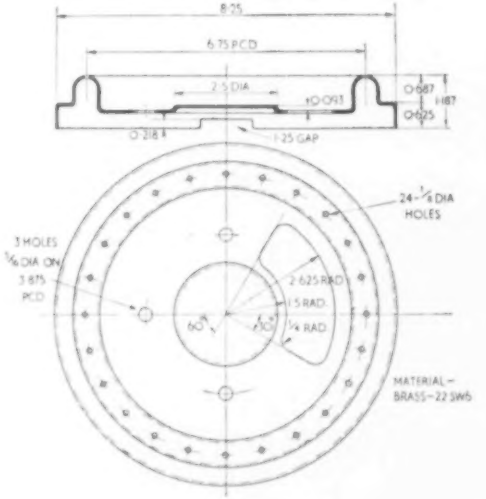
Fig. 2 shows the usual top-hat shape achieved after the piece had been blanked and drawn in the first tool. The design follows conventional practice and the quality of parts required made it necessary to employ a mechanical feed from a reel. A large diameter and a correspondingly large die member is sunk completely in a steel bolster which prevents the die from subsequently assuming a marked degree of ovality. The use of a steel bolster is also advisable as a precaution against bursting the walls in the advent of a cracked die.

The holding ring "B" slides inside the die and apart from the case hardened surface which contacts the component, and the fact that it slides inside the die and over the inner form punch "D", the production of this detail rarely presents many manufacturing problems. The punch "D" is located by means of a small spigot and recess machined in the bolster—the hole drilled and bored in the bottom surface is merely for holding purposes while grinding the diameter and front face. It is, of course, essential to provide this punch with a polished radius where the cup is formed.

The remaining details on the lower tool consist of the material guide "R" and the cushion members for both holding and ejecting the drawn shell; the motion being obtained through the medium of a series of pins "K" passing up through the bolster.

Perfect alignment is essential with tools of this size and the pins "N" are necessary arranged either corner to corner or at the rear of a tool to

Fig. 1.—Despite the apparent shallow profile of this component it required a reverse drawing operation for the formation of the rim diameters. A side slot, numerous small holes and the removal of a substantial portion of the floor added to the problems of production



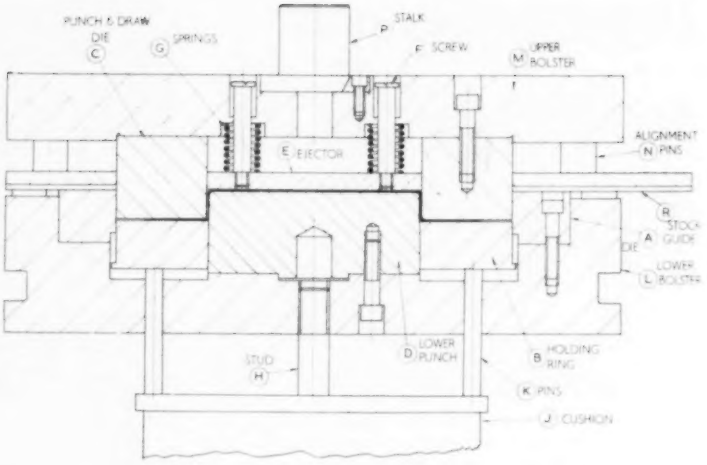


Fig. 2.—The initial blanking and drawing tool followed conventional practice using a mechanical feed attached to the press to pass the material through the tool

give the maximum amount of room to a press setter. They ensure that the top punch "C" enters the lower die "B" with the same amount of clearance between the parts. The punch "C" is again a large item—the degree of draw given to the shell means that a large diameter blank is needed, and this fortunately eliminates a thin section and one liable to distort when hardened. Inside this punch which serves the purpose of acting as a blanking punch and forming die, is the usual top ejector for removing any tight pressing that may adhere to the inner diameter of "C". The ejector is controlled by six heavy-duty springs that overcome any tendency for a sticky detail to remain in the top tool and cause damage during the following feed. The production rate with the tool was 40 per minute.

Finishing the Rim Diameter

The next tool, Fig. 3, is an important one and it requires firm control throughout the drawing process as wrinkles result round the U-shaped diameter. The shell is located inside the forming punch "A" which is a two-part detail, the inner member acting as the embossing punch for the shallow raising in the centre panel. The construction is more efficiently machined when made in two parts because grinding of the flat surface adjacent to the raised portion is much easier when the face is not inside a deep recess.

Surrounding this is the ejector ring "C" which is essential for the removal of the finished shell. This obtains its motion from the pins "F" which pass up through the bolster "E". The retention of this

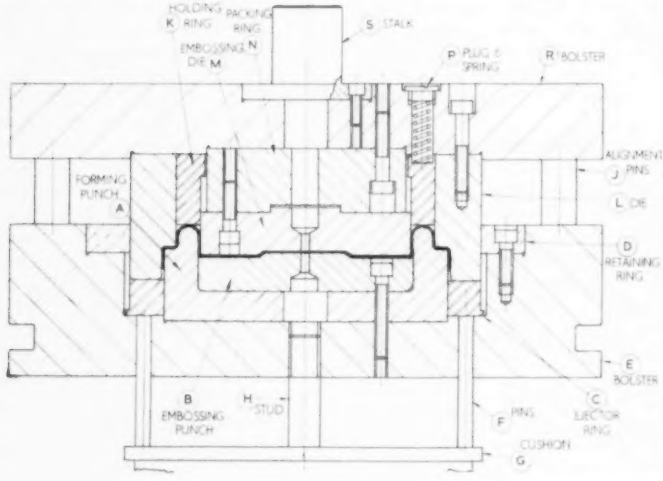


Fig. 3.—An opportunity was taken to form the slight embossing on the reverse drawing tool. This did not create undue difficulties as the raising was merely a few thousandths of an inch. The lower detail on this occasion was a two-part member as this simplified the manufacture of the article

ring in the lower tool is necessary to prevent it from being lost, although it would not fall out when at the top of the die face but probably during storage. For this reason the retaining ring "D" is included in the design.

With all tools of this type firm pressure is essential as the material is drawn over the forming punch, and is achieved in this case with the aid of a holding ring "K" in the top member controlled by stiff coiled springs set in the bolster at "P". Another two-part detail is the embossing die "M" and the packing ring "N", which retain the previously mentioned holding ring. This is not strictly necessary because a single detail if machined on the outside to correspond to the two parts, would serve the same purpose, but a tight fit in the bolster recess would make the part difficult to remove because of its depth inside the forming die "L". Spigots and recesses are employed to ensure all the parts are located correctly and do not tend to move under the influence of pressing a component.

Accuracy in grinding is the keynote during the manufacture of die "L" which again is somewhat large as a precaution against distortion because this item fits closely over the holding ring "H" and the retaining ring "D".

The use of a steel bolster of this size is often difficult unless a forging is available, but the depth of the pocket locating the lower details, makes it almost essential. Again the location of both the top and bottom bolsters by the corner to corner or the rear pins "J" is advisable as damage makes replacements expensive.

Piercing the Holes and Apertures

In contrast to the tools already described, the equipment illustrated in Fig. 4 is surprisingly small but the accuracy demanded is nevertheless higher due to the presence of so many small die inserts and piercing punches; some close jig boring is necessary in order to maintain the clearance round the various cutting members.

Also included in the tool is the larger radial punch for piercing the aperture—thus there are 28 punches each requiring accurate setting to ensure they all pierce their respective holes with little or no burr.

The location of the drawn shell is taken from inside the U shape section and as the previous operation gave a pressing which enabled the shell to seat on the face adjacent to the embossing, a firm bump when the previous tool reaches the end of its stroke gives the required accuracy, and the part can thus be seated on both the curved surface and flat facing with the assurance that the piercing operation will not distort the shell.

A firm hold is obviously necessary, and this is accomplished by means of the pressure plate "B" which serves the dual purpose of holding the shell on the location, and stripping the article from off the numerous punches as the ram rises. For a tool of this type, inserts are necessary as die details and these are depicted at "C" and "D"; while the radial aperture is severed by means of an opening milled in the large die "A".

The remaining items follow conventional practice, a punch retaining plate "H" and backing plate "J" form the chief parts, recessed into the top bolster "M".

Pressings will not remain attached to the upper tool as the stripper "B" allows the punches to withdraw from the material, and generally the removal from the lower die is simply a matter of picking off the part. The use of compressed air is a

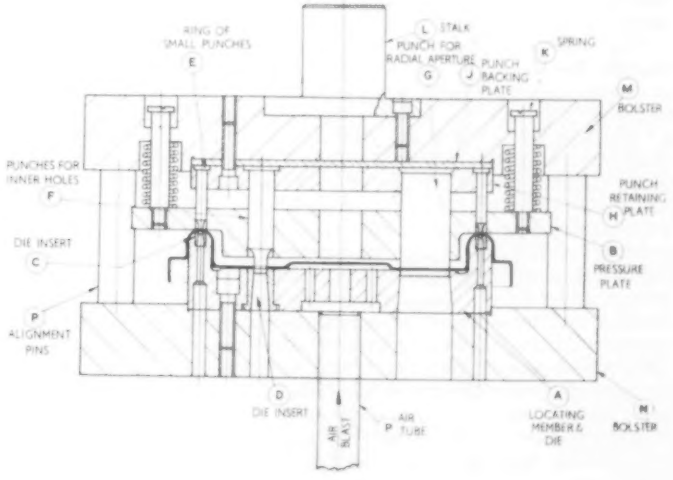


Fig. 4.—Though there are numerous holes in this component, the piercing tool is comparatively small in size and uses air ejection to achieve a quick removal of a part from the lower tool

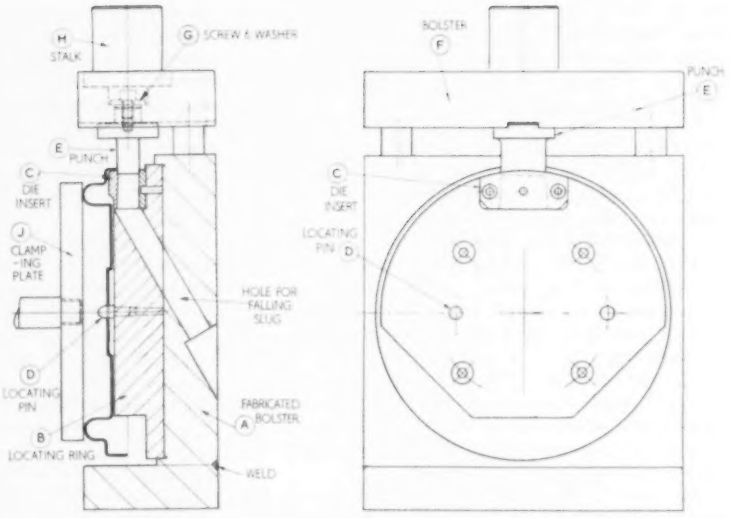


Fig. 5.—Standing a component vertically in a tool is not always possible if a press is small, but on this occasion such a practice resulted in a simple tool compared with the orthodox side moving type of equipment

useful feature for the latter process and a cavity is machined in the die and a series of holes drilled to distribute the air over a wider area; thus on operating a trip valve the piece is assisted from the location and merely requires stacking. However, since the flange is large enough to provide a good handgrip, this latter installation is not an essential factor of the design.

Notching the Side Slot

Though the pressing of the side slot in the previous tool is possible, the design assumes a complicated appearance and the costs rise so much that a separate tool of simpler layout was advisable. Again upkeep is less and re-sharpening does not mean a general dismantling of all the members.

Fig. 5 shows this tool. As side piercing tends to increase manufacturing costs so much the location of a component in a vertical position is the natural solution. The tool is further simplified by using an air cylinder to push the formed component against the location surface, the latter equipment being clamped to the press bed and operated independently of the tool.

A fabricated angle plate "A" is the basis of the lower member and the item is recessed to carry the location ring "B", but is cut away for a considerable portion of the outside diameter to reduce the area of location and ensure that the workpiece will seat immediately over the insert diameter "C" rather than on the sides of this ring. This can occur if the sides are distorted a few thousandths of an inch and assume a slight degree of ovality.

The inserted die is a two-part item and fits into a milled recess machined in the location ring. With all tools of this type the removal of slugs is often a serious problem, especially when the piece removed is square because the sharp corners can become jammed across an opening or with further falling slugs, and a situation is created whereby the opening is filled and punch breakage soon results.

Because of this a long rectangular hole is slotted in the location ring to break through near the recess machined for the insert, and with a matching recess in the vertical portion of the bolster "A", the falling slug has no difficulty in dropping clear once the punch has completed its task.

The final item on the lower tool is the location plug "D" which is necessary to ensure the slot is pierced relative to the punched holes, and a pin, ground several thousandths of an inch smaller that the hole size, is adequate for the accuracy required.

Despite the large dimensions of the top tool, the design is simple and is merely a punch set into a steel block with provision for aligning it with the lower bolster. The punch "E" has the usual flats ground on the head and is securely held by a socket-head screw recessed into the bolster.

General

An operation for which a press was not used was the trimming stage, interposed between the piercing of the holes and a notching operation; slight distortion of a rim takes place although the profile is symmetrical, and a light skim on a capstan using a simple flat plate as a location medium and an air cylinder to hold it securely against the cutting pressure is required; a high spindle speed is necessary as the material is semi-hard rolled brass.

(*Continued in page* 435)

The Design and Use of

MODERN SLIDE RULES

By

J. FERDINAND KAYSER, F.I.M., A.Met.

IN spite of the advent of calculating machines costing hundreds and in some cases thousands of pounds, the slide rule is still the most widely used calculating device in industrialized countries, though it is probable that in the world as a whole the Abacus still holds pride of place. Nevertheless, a surprisingly large number of people view a slide rule with suspicion and believe that its use may lead to serious errors and that at best it only gives approximate results and consequently they prefer to use logarithms.

Errors may be made with any calculating aid but many people find it more difficult and take much longer to determine the value of, say, $0.687^{-2.7}$ by the use of logarithms than by the use of an appropriate slide rule. Schoolchildren are required to multiply, say, 2.54×31.25 ($= 79.3750$) and to give the exact answer. If, however, one wished to convert $31\frac{1}{4}$ in. to centimetres one would not usually require the answer to the 4th decimal place and the slide-rule result, 79.4 would be adequate. Indeed the data upon which most ordinary engineering calculations are based seldom justify more than three significant figures in the answer.

Arnold(1) has stated that the probable error of computation with a slide rule is about $\frac{1}{2}\frac{1}{0}$ of 1 per cent. To statisticians "probable error" signifies 0.6745 times the standard deviation, σ, and plus and minus 0.6745 times includes 50 per cent of all the readings, hence the term "probable error", *i.e.*, the error which is as likely to be exceeded as not.

If Arnold used the expression in its statistical sense then the standard deviation (in parts per thousand) would be 0.74. Six times the standard deviation, σ, includes 99.73 per cent of all readings; four times σ includes 95.45 per cent of them and twice σ includes 68.27 per cent. Hence according to Arnold 99.73 per cent of all his readings would fall within $\pm$ 2.22 and a true reading of 1,000 might be read anywhere between 997.78 and 1,002.22.

The accuracy and speed with which an operator can use a slide rule is a matter of personal skill and experience and every user should satisfy himself that he is skilful enough to be able to use it with sufficient accuracy. A good way of doing this is to make a number of computations with a slide rule and then with 4-figure logarithms and determine the standard deviation of the differences between the two sets of readings. The writer's standard deviation, in parts per 1,000, for multiplication and division of 4-digit numbers varies between 0.5 and 0.7. One of his colleagues can compute with a standard deviation of 0.3 to 0.35, and in general the standard deviation of the error of engineers and physicists who habitually use a slide rule is less than 1 part per thousand. Dr. McGloughlin (Gillette Industries Ltd.) in a private communication also reported a standard deviation, in parts per thousand, less than 1. One does, however, occasionally find a user whose standard deviation may be as high as 10 parts per thousand.

It appears that the results given by a slide rule will always be accurate within the range $\pm$ 3 parts per thousand while many operators can achieve $\pm$ $1\frac{1}{2}$ parts per thousand.

The scale of logarithms and the trigonometric scales can be read with the same degree of accuracy as the fundamental scales if sines of angles 45 deg. $< \alpha <$ 90 deg., and cosines of angles 5.5 deg. $< \alpha <$ 45 deg. be read with the aid of the $\sqrt{1-x^2}$ scale, since $\sin \alpha = \sqrt{1-\cos^2 \alpha}$ and $\cos \alpha = \sqrt{1-\sin^2 \alpha}$.

At the same time as one is determining ones own error it is instructive to time the operation of multiplication, division, etc., and in general it will be found that one can compute two to three times as fast with a slide rule, as with four-figure logarithms.

The purpose of the slide rule is to speed up the process of computing and if one desires to read as accurately as possible it is obvious that the user will choose to work with the C and D scales in preference to the A and B scales. Only experienced users of the conventional type of slide rule know that in spite of every possible artifice in manipulation, situations will always arise when resetting of the slide becomes necessary. These end reversals which arise so frequently when working with the C and D scales hamper the calculating process in

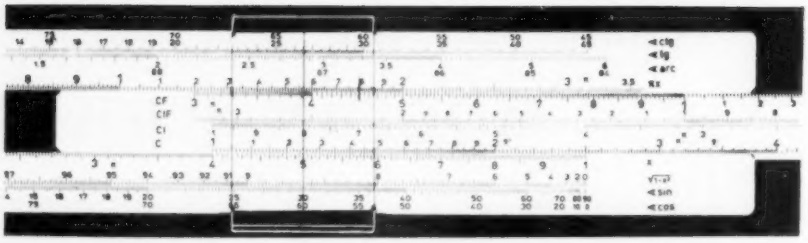


Fig. 1

that they amount to a new start of the calculating process, which is exactly what the calculator tries to avoid.

A useful addition to the simple slide rule is a reciprocal scale which is usually marked CI (C inverted) and should also be marked $\frac{1}{x}$. The purpose of this scale is not merely to serve in conjunction with the C scale as a monograph for finding reciprocals but to permit a multiplication to be converted to a division and vice versa.

The procedure for finding the value of $\frac{a \times b}{c}$ is well known but it is not generally appreciated that a reciprocal scale permits the same procedure for finding the value of $\frac{a}{b \times c}$.

An example of this is shown in Fig. 1; for $\frac{64}{16 \times 8} = 0.5$, 16 (scale C) is set over 64 (scale D) and the answer is read below 8 (C1 scale) on scale D, *viz.* 5, and by inspection 0.5.

A reciprocal scale also facilitates determining the value of such expressions as $a \times b \times c \times d$ or $\frac{1}{a \times b \times c \times d}$ which can be solved by alternate division and multiplication, every second one of the factors being set on the reciprocal scale.

Even this procedure does not always have the desired effect and when the scale projects too far to the right or to the left it is necessary to reset it. Slide rules are, however, now available that allow one to work continually with full-length scales without encountering the need for an end-to-end exchange. To this end the A and B scales are replaced by two scales that by international custom are called "folded scales" and are marked C F and D F respectively. The C F and D F scales are identical with the C and D scales but are displaced laterally so that the index 1 is approximately in the centre of the rule.

Folded scales should, of course, always be accompanied by a folded inverted replica CIF as in dealing with numerous factors in the numerator and denominator such a scale is indispensable to uninterrupted operation. Dr. Jaegar has pointed out that a displacement of 10 suggests itself because this would place the 1 on the DF scale exactly opposite the middle of D. In internationally accepted practice, however, the ratio π for engineering slide rules, and 360 for commercial slide rules have been adopted as more practical, although this brings 1 slightly off centre in the DF scale. For engineering slide rules π has been chosen in order to simplify computations involving it (π) and for commercial types of slide rule the factor 360 has been adopted for its usefulness in interest calculations, 360 being the number of days of interest in the year counting by the so-called ordinary method.

One face of a slide rule provided with folded scales is illustrated in Fig. 2. It will be noticed that the index 1 of the CF scale will necessarily always be aligned with the same value on DF with which the index 1 of C is aligned on D and as pointed out in the instruction book the two pairs of scales work together as a team and the necessity to reset the slide never arises.

Slide rules have been known and used for more than three centuries and from a perusal of J. E. Thomson's book "A Manual of the Slide Rule" it is obvious that almost all the present-day refinements were known more than one hundred years ago and that from a mathematical point of view there is nothing that is not known about the possibilities of the slide rule, which extend far beyond simple multiplication and division.

(*Continued in page* 435)

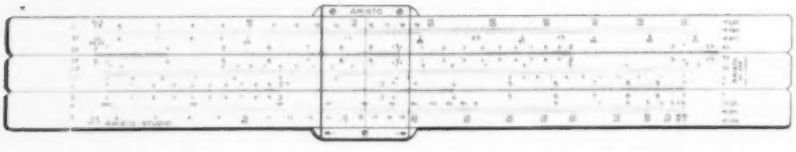


Fig. 2

Modern Slide Rules

(*Continued from page* 434)

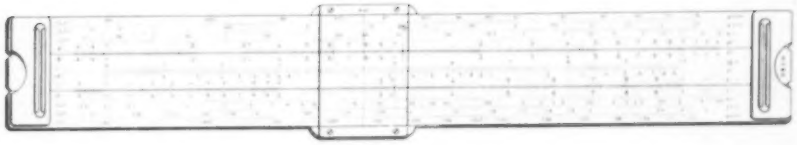


Fig. 3

The writer's first slide rule had only four scales, A, B, C and D, but he now prefers to use the one illustrated in the figures which has 22 scales, of which he finds the folded scales particularly efficacious and he can confirm Dr. Jaegar's[2] statement that "It is always a gratifying experience to observe the astonishment even of shrewd slide rule computors when their first guided try-out shows them this short cut way in slide rule technique in which no resetting of the slide occurs."

For multiplication and division the DF, CF, CIF, CI, C and D scales are used in conjunction with one another. There are six (log-log) scales which together cover the range $10^{.5}$-10^{5}, with the exception of the range 0.99-1.01.

These scales are used for computing a^n, where the exponents may be positive or negative, whole numbers, fractions, or decimal numbers.

An example of interest to sheet metal engineers is the formula for pressure developed during explosive forming, *viz.*

$$P = 155 \left(\frac{W^{\frac{1}{3}}}{R^{1.15}} \right) \sqrt{V_D}$$

where P = peak pressure (lb. per sq. in.).
W = weight of explosive (lb.).
R = distance from explosive (ft.).
V_D = detonation velocity of explosive (ft. per sec.).

The respective values might be

$$W = 0.15,\ R = 0.5 \text{ and } V_D = 25{,}000.$$

$$\text{Hence } P = 155 \left(\frac{0.15^{\frac{1}{3}}}{0.5^{1.15}} \right) \sqrt{25{,}000}$$

$$= 155 \left(\frac{0.5315}{0.450} \right) 158.1$$

$$= 28{,}900$$

Computed by four figure logarithms P = 28,890.

It is an interesting exercise to compute x in such an equation as $x^{4.8} - 2.23 = 0$ ($x = 1.182$) by the use of C and LL2 scales (Fig. 3). The values of x to satisfy such equations as

$$x^2 + 28.32x + 55.5 = 0 \ (-26.2, -2.12)$$

can be quickly computed by the use of a fundamental scale and the corresponding reciprocal scale.

If a slide rule is used only for multiplication and division, no difficulty will be encountered in following the instruction books that usually accompany it, but for more advanced computations a thorough knowledge of algebra, logarithms and trigonometry is essential. Arnold's book is then easy to follow and those who understand German will find the 1960 edition of Stender's[3] "Der Moderne Rechenstab" (The Modern Slide Rule) particularly useful.

References

1. The Slide Rule. J. N. Arnold. Prentice-Hall, Inc. New York, 1954.
2. Aristo Bulletin, No. 1. Dennert and Pape, Hamburg. September, 1958.
3. Der Moderne Rechenstab. Richard Stender. Otto Salle Verlag, Hamburg.

Producing a Special Oil Drain Ring

(*Continued from page* 432)

Wrinkling was expected after the reverse drawing stage and though this was present it appeared only as a light wave at the edge of each shell. Again by piercing so large an aperture it was thought that it could also cause warping of the floor, but the embossing undoubtedly strengthened that portion and limited the error to a matter of three or four thousandths of an inch.

NEW POWER-PRESS COMPANY FORMED

Closer Collaboration Between Wickman and Schuler

WICKMAN LTD., Coventry and L. Schuler, A.G., Germany announce the formation of a jointly owned British Company, Schuler Presses Ltd.

The new company has been formed to establish the manufacture of certain Schuler presses in the United Kingdom and to provide a U.K.-based engineering and after-sales service to all Schuler press users.

Wickman Ltd. will act as exclusive sales representatives for the complete range of Schuler presses, and will also offer a complete tool-design and tool-making service.

CONTROLLING THE QUALITY OF TINPLATE

Automatic Recording of Control Data by Printed Ticket and Punched Tape

WHEN tinplate is shipped in sheets, quality can be effectively controlled by separating the sheets in accordance with specified standards. However, when tinplate is shipped in coils, defects are scattered throughout the coil, and quality control becomes difficult.

Airborne Instruments Laboratory (AIL), a Division of Cutler-Hammer Inc., of Deer Park, New York, have devized a system for electro-tinning lines which makes use of existing sensing stations and automatically records the required quality control data in two forms, printed ticket and punched paper tape. The system is adaptable: connected to any electro-tinning line, it will record reliably the extent of deviations in predetermined characteristics for each coil in production runs.

Major Units

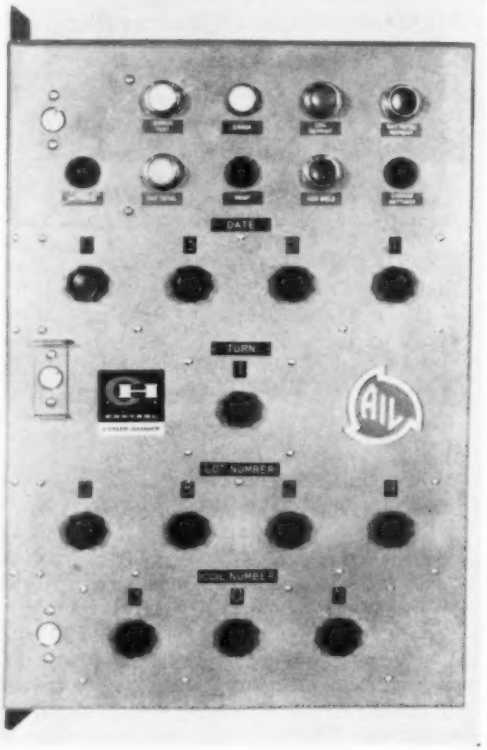
The coil data accumulation system consists of a visual inspection station, a main cabinet, and an output cabinet, together with interconnections to existing sensing gauges on the electro-tinning line.

When a coil is entered into the line, the operator sets the knobs on the manual input cabinet (Fig. 1) to indicate the date, turn, crew, coil order number, temper base weight, line operation, and strip width. Large in-line numbers located above each group of knobs help the operator to adjust the knobs for the correct settings. The numbers set by the knobs are converted into typewriter code signals by switching circuits. Numbers representing the time are generated by a clock in the cabinet and are also converted into typewriter code. The typewriter code signals are then transmitted to the electric typewriter in the output cabinet, which records all the information received from the manual input cabinet on a preprinted form.

The visual inspection station is located at the end of the tinning line near the shear. Defect buttons on the control panel of the station correspond to the types of visual defects that may be present in the strip. When the inspector observes a defect in a strip passing by the inspection station, he presses the button on the panel corresponding to that defect, and holds the button down until the defect is no longer observed in the strip. A lamp located above each defect button, lights during the time that the defect button is depressed.

The main cabinet is located near the shear at the

Fig. 1.—The manual input cabinet panel



output end of the electro-tinning line. It contains three independent computers, a comparing circuit, and a trouble indicator. Each of the computers in the cabinet is completely enclosed in a dustproof cabinet; a number of external test points are provided for operational checks. The three independent computers make for maximum reliability. If only two computers are used and one of them fails, it would be impossible to determine which of the two was faulty until both had been checked. Until the faulty computer was repaired, continued fully checked operation would be impossible.

The output cabinet is located near the shear at the output end of the electro-tinning line. It contains a typewriter in the top section of the cabinet and a spare typewriter, in a sealed package, in the lower section of the cabinet. Dust shields are provided to protect the operating parts of the typewriter.

A coil profile-data accumulating system is provided giving a printed record of the location of all defects in 10-ft. increments.

Operation

The data accumulation system uses four standard types of AIL logic plates, together with magnetostrictive lines. The logic plates accept the signals from the gauges, delay each signal by an amount corresponding to the distance between the gauge and the shear, accumulate the total output for each type of defect, and provide properly coded signals to operate the printer and cause the totals to be printed. To minimize the number of components in the system and thus increase its reliability, a single logic circuit processes each of the defect classifications in turn.

The magnetostrictive lines are used to store the total number of feet of each type of defect, and also to provide the necessary delay between the time that a defect relay operates and the time that the defect reaches the shear. The shear is taken as the reference point for the delay system.

The system is internally compensated to correct for the timing errors that are introduced because some gauges are located at significant distances from each other. A simple knob adjustment is all that is required if a particular gauge is relocated.

A comparing circuit accepts the outputs of the three identical computers. If all three outputs agree, the comparing circuit gives an output identical with the inputs. If one input does not agree with the other two, the output is determined by the two that do agree, and the system continues to operate without interruption. A trouble lamp indicates that one computer is not operating properly. When the operator turns off the computer that is faulty, the other two computers continue to operate the printer and compare outputs; thus, the operation of the system is double-checked. During the time that the numbers in the storage section are being printed, the rest of the computer is free to accept data from the next coil. This gives enough time for the printing to permit operation of the printer considerably below its rated speed, thereby enhancing its reliability.

Design Features

The data accumulation system has been designed to satisfy three prime objectives: (1) to prevent errors from originating within the system, (2) to provide reliable uninterrupted operation, and (3) to reduce maintenance to the absolute minimum.

The AIL logic plates used throughout the system are operated so that all electronic components operate well below their rated powers. The plates have been fully tested for reliable operation under severe military environments coverin g about twice the range characteristic of the strip electro-tinning line. The plates have operated satisfactorily in several large-scale computer systems that are part of advanced electronic equipment under development of AIL. In addition to the rugged construction of the logic plates, all components are encapsulated to protect them from corrosive fumes and humidity. Standard Cutler-Hammer enclosures are used to house the equipment, and the individual electronic packages are equipped with dust-protection enclosures. All wiring and interconnections are made without the use of plug-in connectors, except in the enclosed electronic packages.

There are no vacuum tubes in the system and no moving parts in the computers, and the absence of parts that deteriorate with use in the magnetostrictive lines gives them an unlimited life.

No periodic maintenance is required on any part of the system because the number of power-consuming electronic circuits has been kept small enough to permit complete enclosure without any ventilation. Effective cooling is accomplished entirely by conduction and radiation.

In the event of power failure, the equipment will not lose any stored information, and in addition will continue in full operation, accumulating data during any power failure up to two hours. This safety feature uses a floating standby power source to operate the unit during line power failure. The nickel-cadmium batteries have a life of 20 years, and need be checked only once a year. The change to standby power and back is automatic, requiring no attention from the operator, and all switching between standby and line power is done without relays or other moving parts. Recovery is sufficient to protect against multiple power failures up to two, two-hour failures within a 24-hour period.

BLANK DIMENSIONS FOR DRAWN RECTANGULAR BOXES

By the late BARUCH SPECTOR, P.E.

DURING the normal course of business, the problem arose of finding the dimensions of a blank (Fig. 1(*a*)), for the box shown in Fig. 2(*b*). Many attempts have been made to find a satisfactory means of allowing for the material taken up on the corners, when drawing components of this nature and a varied number of assumptions have been suggested. It was, however, felt that a serious attempt should be made to formulate a method that could be applied to any number of similar examples, and the advice of mathematician Kenneth Kunen was sought. Copies of two articles dealing with this subject, published in "American Machinist," and a book by E. W. Bliss entitled "Computation for Sheet Metal-Working Operations" were consulted but it was apparent that there is no hard and fast rule for assessing the distance to the neutral lines. It can be easily seen that in all cases this distance depends on the thickness of the sheet; Bliss suggested using $0.4t$, where t is the thickness of the sheet, but anything of that order is reasonable and in the original example $\frac{1}{3}t$ was used. However, mathematics being the exact science it is, Kunen suggested that it would be better completely to ignore the sheet thickness and derive a formula to suit any case.

Accordingly he constructed a box, shown in Fig. 1(*c*), of thickness dt, and having an outline of the same shape as the neutral lines, this being a fairly safe assumption for a box of infinitesimal thickness, since the geometric definition of a line is the intersection of two planes without thickness. After comparing the two articles in the "American Machinist," it was decided to use the method employed in the September 4, 1930 issue, to estimate the total area of the box.

Accordingly, the box was divided into seven elements with areas A1 to A7, and the following dimensions defined:

h = height of the vertical section of the walls (excluding radius).
L = overall length of the box.
m = length of box (excluding radius).
R = radius of horizontal bends.
r = radius of vertical bends.
t = total thickness of sheet.
dt = thickness of neutral lines.
v = length of short sides of box (excluding radius).
W = overall width of box.

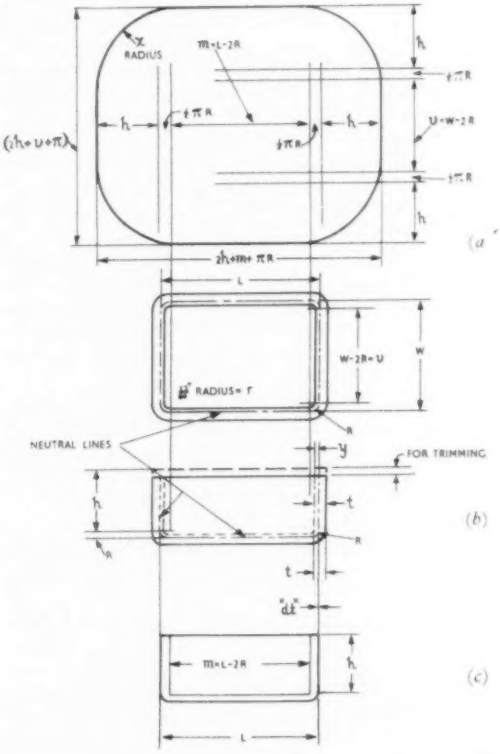


Fig. 1 (a) (b) (c).—The blank, box and Kunen's hypothetical configuration assuming a box of infinitesimal thickness

x = radius of corners of the blank.
y = distance of inside of box to the neutral line.
$z = h$

It was assumed, at this stage, that the bottom corners of the box were each one-eighth of a sphere and that all the walls would be of the same thickness as that of the original sheet.

By inspecting Fig. 1, it was possible to establish a number of relationships:

$m = L - 2R$ .....(1)
$v = W - 2R$ .....(2)

and also the overall dimensions of the blank,

$2h + v + \pi R$ .....the width of the blank.
$2h + m + \pi R$ .....the length of the blank.

The seven elements, A1 to A7, could also now be given their respective algebraic limits:

A1....four vertical corners.....$2\pi Rh$.
A2....four common corners .....$2\pi R^2$.
A3....two short horizontal corners .....πRv.
A4....two short side walls .....$2hv$.
A5....two long walls.....$2hm$.
A6....two long horizontal corners. .....πRm.
A7....base. .....mv.

The summation of these elemental areas will, therefore, give the total area of the box.

$\therefore \Sigma A = mv + 2h(m + v) + \pi R(2h + m + v + 2R)$ .....(3)

Having now established the total area of the box, and the overall dimension of the blank required, equations (1) and (2), the total area of the blank can be stated, and is:

$\Sigma AB = (2h + v + \pi R)(2h + m + \pi R) - 4x^2 + \pi x^2$ .....(4)

Simplifying:

$\Sigma AB = 4h^2 + \pi^2 R^2 + 2h(m + v) + \pi R(4h + v + m) + mv + x^2(\pi - 4)$ .....(5)

Equating the area of the box, equation.....(3), with the area of the blank, equation.....(5), it should be possible to obtain an expression relating the corner radius of the blank, x, with the other variables.

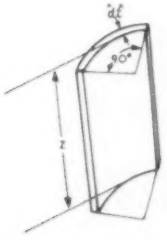


Fig. 2.—Details of bent side dimensions, vertical and horizontal

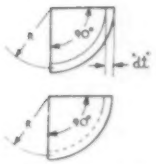


Fig. 3.—Corner dimensions

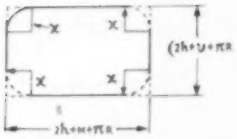


Fig. 4.—Graphically equating the areas of the box and the blank

Equating.....(3) and (5),

$mv + 2h(m + v) + \pi R(2h + m + v + 2R) = 4h^2 + \pi^2 R + mv + 2h(m + vs) + \pi R(4h + v + m) + x^2(\pi - 4)$.

Rearranging this equation:

$4h^2 + \pi R(2h - 2R) + \pi^2 R^2 + (\pi - 4)x^2 = 0$.

or,

$4h^2 + \pi R(2h - 2R) + \pi^2 R^2 + x^2(\pi - 4) = 0$.

$$\therefore x = \sqrt{\frac{4}{4-\pi}.h + \frac{\pi}{4-\pi}.R(2h + R[\pi - 2])}$$

$$x = \sqrt{4.66h^2 + 7.32hR\ 4.18R^2}$$

It can now be seen that the radius of the corner of the blank is dependent only on R and h, and an initial calculation, using this formula, should take only a matter of minutes.

It must be remembered, however, that this theoretical analysis of the problem will serve only as a guide, and although being very close to the truth, should not be used with the exclusion of that valuable authority, experience.

Finally, applying the Kunen formula to an example, a box, which is to be drawn from $\frac{1}{4}$-in. thick sheet steel, having inside dimensions of 12 in. long, 10 in. wide and 3 in. deep, including a small amount for trimming with all round corners $\frac{1}{2}$ in. radius, for a first approximation, y and the distance of the neutral line from the inside of the box, can be ignored. Consideration can be given therefore to the outline of the neutral lines only.

Using equations.....(1) and (2),

$m = L - 2R = 12 - 1 = 11$
$v = W - 2R = 10 - 1 = 9$
$h = 3 - R = 3 - .5 = 2.5$

$$\pi R = \frac{\pi}{2} = 1.57.$$

Substituting for R and h in.....(6),

$x = 4.66 \times (2.5) + 3.66 \times \frac{1}{2}(5 + 1.14 \times \frac{1}{4})$
$= 4.66 \times 6.35 + 1.83 \times 5.57$
$= 2.91 + 10.2$
$= 6.27$

Also,

$2h + v + \pi R = 2 \times 2.5 + 9 + \frac{1}{2}\pi$
$= 15.57$.

A Mechanism for Counting the Strokes of Crank Drive Presses*

By

A. D. KIRITSEV

IN forge shops at the present time determination of the number of fully worked forgings or components is carried out by calculation or weighing, which involves time losses and expenditure of manual labour.

Existing methods of automatic counting of finished components have not received wide application, since they are either complicated, expensive and specially made for counting a number of components of a definite dimension or shape only. The adaptation of these counters for counting other components is linked with wastage of time and definite financial losses.

The author of this article has suggested a design of counter for crank drive presses with electric drive motors. The counter is working in the forging and stamping laboratory of the Zhdansk Metallurgical Institute. This counter accurately indicates the number of working strokes of the press, irrespective of the dimensions, weight, design, method of delivery of the billet and discharge of the component, design of the die or even the machine itself; it does not take up working space, and has no mechanical links with the moving components of the press.

The working principle of the counter is based on the change in current amplitude of the electric drive motor of the press during its operation. The electric drive of crank drive, forging and stamping presses is normally operated by an asynchronous electric motor with a flywheel. The nature of the change in the current amplitude of such an asynchronous electric motor is shown in the oscillogram, Fig. 1.

Section I corresponds to the period when the electric motor is started up, when the current amplitude is a maximum. After the starting up period there should be a period of steady running (section II), when the energy is mainly expended in overcoming the frictional forces in the transmission and in the hub of the flywheel. Section III corresponds to the movement of the crosshead, but no work is done in deformation during this period; the crosshead carries out its downward and upward movement, and under such conditions of idle load running the current amplitude rises only slightly, due to the fact that the movement of the crosshead is mainly brought about as a result of the flywheel energy.

The change in the current amplitude during the period of the working stroke is shown in section IV. As may be seen, the current amplitude during the working stroke, I_w, is less than the current amplitude in the starting period, I_s, and greater than the idle running current amplitude, I_{ir}, of the electric motor.

On the basis of the nature of the change in the current amplitude, the circuit of the counter was chosen on the principle of the use of a maximum current relay, so that the counting device is switched on at the moment when the current amplitude of the electric motor I_w, is less than the starting current amplitude I_s, and greater than the idle-running current amplitude I_{ir}, i.e., the counter is switched on at the time of the working stroke during the process of deformation.

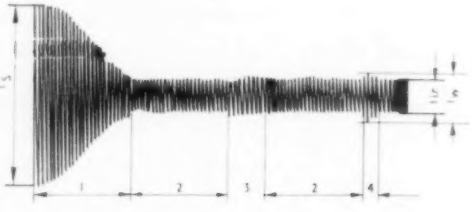
Into the circuit of the electric motor, Fig. 2, are inserted in series in one of the phases, the maximum current relays 2 and 3. The contacts of relay 2 are normally closed, while those of relay 3 are open. The winding of the electromagnet 4, is connected in parallel with one of the phases of the electric motor through the contacts of the relays 2 and 3. The counter device 5, is an ordinary impulse, decimal counter, the numbered discs of which rotate at each movement of the electromagnet 4.

All the components of the counter are contained in a small box, which may be fastened on the side of the column of the press.

In the wiring circuit adopted, during no load running of the electric motor and during starting up, no current passes through the circuit of the winding of the electromagnet, and consequently the counter will not operate. When the electric motor is started up, the maximum current passes through the wind-

(*Continued in page* 441)

Fig. 1



* Translated from *Kuznecho-Shtampovochnee Proizvodstvo* 1960, **2** (3)

Counting the Strokes of Crank Drive Presses

(*Continued from page* 440)

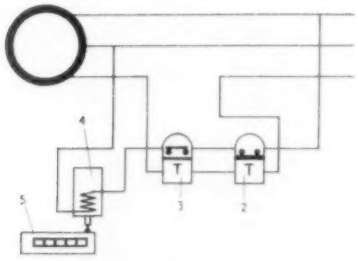


Fig. 2

ings of the relays, causing relay 2, in which the contacts are normally closed, to operate; the contacts move apart, and no current flows through the circuit of the electromagnet of the counter device. Relay 2 is calibrated according to the maximum current loading. Relay 3, in which the contacts are normally open, operates under the action of the maximum current, the contacts are closed, but current will still not pass through the circuit of the electromagnet, since the contacts of relay 2 are apart.

During idle running, when the current is small, the contacts of relay 2 are closed, while those of relay 3 are open, since this relay is calibrated in accordance with a current which is greater than the idle running current. The electromagnet, in this instance is not switched on. Thus, when the motor is started up, and during idle running movement of the crosshead, the counter device does not operate.

The relays are adjusted in such a way that the working stroke current causes the contacts of relay 3 to close, while those of relay 2 remain normally closed, since under these conditions the current is less than the current of the starting-up period (Fig. 1), and the current passing through the circuit of the electromagnet, sets in motion the plunger connected with the counter device.

The setting of the current to operate the relay is carried out experimentally according to the idle load current and the current for starting up the electric motor. This setting does not take more than 10 to 15 minutes, and is carried out while the counter is being fastened to the press, and is periodically checked during normal operation.

Where the electric drive motor is started up relatively seldom, the counter circuit can be simplified at the expense of cutting out the maximum current relay, 2, which is calibrated with the starting up current.

Where a plunger type relay (RE 2100) is used in this circuit, it may be still further simplified, by cutting out the electromagnet and relay 2. In accordance with this variation of the circuit, the plunger relay (RE 2100) is connected directly to the counter.

Production of Electric Water Heaters

(*Continued from page* 428)

press for heat-treating the springs after they come off the press. Every thermostat is given a "soak" test after which the temperature setting dial is adjusted to specification.

The immersion heaters consist, in general, of either elements of the type used in the sink heater contained within a copper tube of relatively large diameter, or are of the small-diameter type wound in a copper tube of about $\frac{1}{4}$ in. dia. which is subsequently formed to the shape required.

The element tube and the thermostat sheath are silver soldered into the usual heavy brass top which is threaded for insertion into the hot water tank.

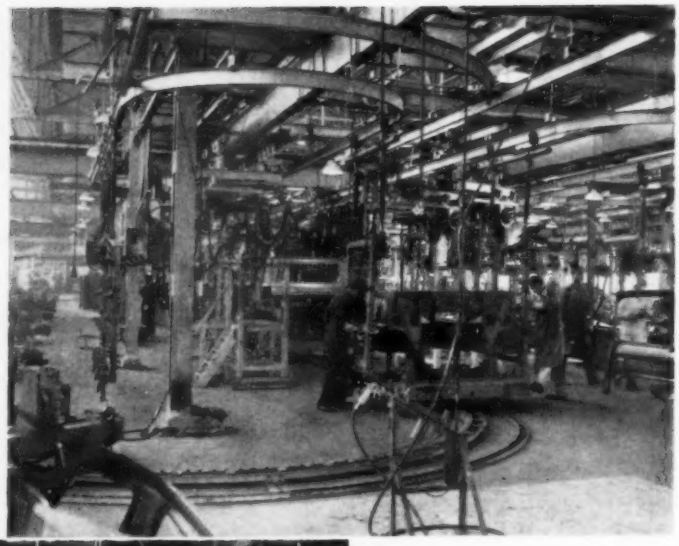
Stanelco electro-gas equipment is used for the silver-soldering operation, after which the joints are shotblasted in Guyson equipment. Subsequently, in two spray booths, Bullows guns and a pressure-pot fitted with an air stirrer motor, are used to apply a coating of metallic copper paint, afterwards stoved in a Stordy oven. Some immersion heaters are tinned, according to requirements.

FINISHING INDUSTRY AMALGAMATION

IT is announced that R. Cruickshank Ltd., of Camden Street, Birmingham 1, industrial chemical manufacturers and suppliers of chemicals and plant used in the electro-plating and metal-finishing industries, has now joined the Forestal Group of Companies of The Adelphi, John Adam Street, London, W.C.2. This acquisition forms an extension of the programme of diversification into the chemical manufacturing industry which is being carried out by Forestal. It is intended that the technical resources of Forestal shall be applied to extending the range of products and the level of technical service provided by R. Cruickshank Ltd. It is hoped that the substantial manufacturing capacity of the Forestal plants throughout the world will improve the competitive position both at home and in overseas markets.

The company will continue under the guidance of Mr. A. J. L. Nash as managing director and the name of the company will remain unchanged.

IMPROVED PRODUCTION METHODS FOR "BEDFORD" CABS



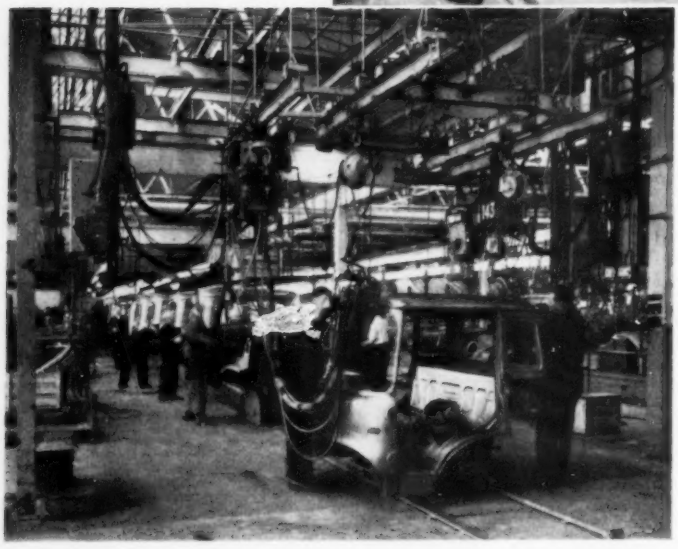


Fig. 1 (above).—Suspended "gate" fixtures are used in conjunction with precision-built jig trucks to build the new all-steel, forward-control Bedford TK cabs. This view of the cab-welding conveyor at Luton shows how the major units are locked on to the jig trucks travelling on the floor conveyor

Fig. 2 (left).—Seam welding the roof panel to the main structure of the cab shell, now rigidly welded together, is done by portable seam welders designed and made by Vauxhall Motors. In the background is the cab metal-finishing conveyor where the doors are hung, and the cab made ready for the paint shop

WITH the introduction of the new-design forward control Bedford cab, Vauxhall Motors have drawn upon experience gained from the successful techniques employed in the manufacture of Vauxhall 4- and 6-cylinder car bodies, and applied these techniques to cab production.

After work began on the new cab project all was ready—including a new conveyor line—in time for full production of cabs to start up about 10 months later. Excluding die drafts, models, patterns, templates and other pre-production operations, the sheet-metal engineering division have made and proved out 942 new dies and 255 inspection checking fixtures. The heaviest die weighs 21½ tons, and the new cab and associated sheet-metal items totalled 383 separate pressings.

The body assembly production engineering division built and proved out 385 new assembly fixtures. In addition they have designed, built and installed 155 spot-welding guns and several spot-welding and projection-welding machines.

Plastic master templates for the construction of

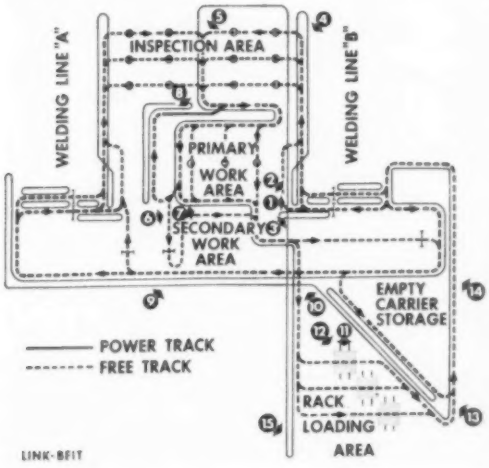
(*Continued in page* 458)

"POWER-AND-FREE" CONVEYOR SYSTEM FOR CHRYSLER BODY-ASSEMBLY LINE

Built-in Programming Makes Many Handling Operations Automatic

A POWER-AND-FREE conveyor system that practically "thinks for itself," is teamed up with two of the largest automatic welding lines in the automotive industry at Chrysler's Ohio Stamping Plant in Twinsburg, Ohio, U.S.A., southeast of Cleveland, as part of Chrysler Corporation's multi-million-dollar changeover to unitized body-and-frame construction.

The conveyor system is capable of handling 700 units hourly. It receives complete "Unibody" rear floor pan, rail and skin assemblies from two 658-ft. resistance-welding lines and carries them through inspection stations to the shipping area. The work is routed over alternate paths as dictated by inspection requirements and the "traffic conditions" of the system.



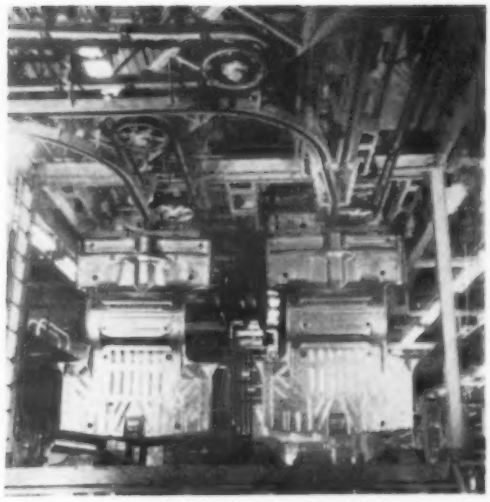


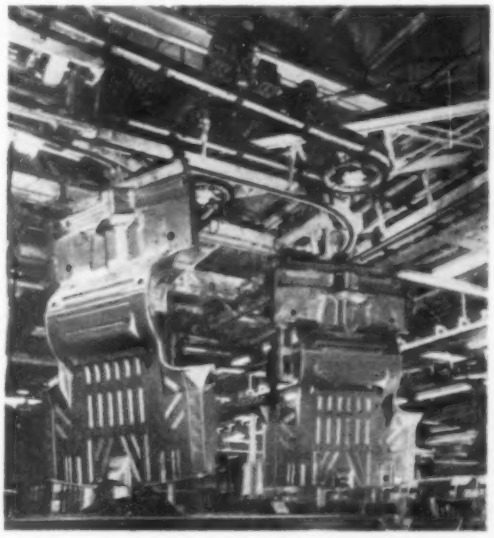
Fig. 1 (above).—At the start of the system, floor-pan assemblies are positioned, two at a time, by up-enders onto a Link-Belt lift station, raised to proper elevation and picked up by hooks on free carriers in the power-and-free conveyor. A selector switch controls lift to suit pans of different lengths

●

Fig. 1a (bottom left).—Arrangement of conveyor system. Numbers show photo. locations

●

Fig. 2 (below).—Carriers with floor-pan assemblies on two separate power-and-free pick-up conveyors converge onto a single power-and-free distributing conveyor which delivers the floor-pan assemblies to the inspection areas. Switches on the free track open and close automatically



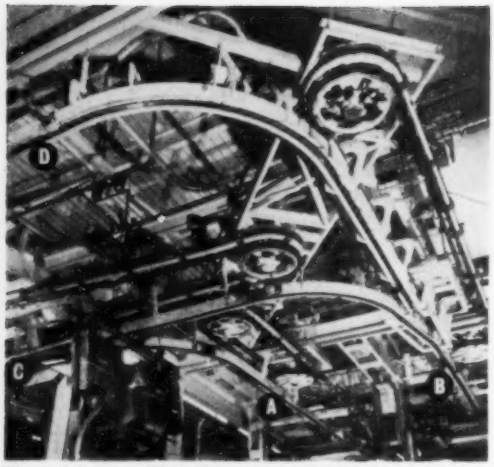


Fig. 3 (above).—Three drives on a common frame—driven by one motor—synchronize the two pick-up conveyors (A and B) with the distributing conveyor (C). A switch in one pick-up conveyor automatically sends half of the production into a gravity storage bank (D) if the inspection area falls behind production

The change to unitized construction is one of the most dramatic advances in American automotive design. While conventional automobiles have required two major assemblies, a welded body bolted to a chassis frame, in unitized construction the components of body and chassis are welded into a single unit. The body is framed like bridge trusses. The result, according to Chrysler engineers, is twice the torsional strength of conventional frame models, 40 per cent more beam strength and added passenger room and comfort.

The inspection stations were installed to assure the highest possible quality in workmanship. The 860 machine welds in each floor-pan assembly have to be thoroughly inspected, and the final product must be one that meets high standards of structural design by virtue of the correct placement and quality of all welds.

Welding Operations

Seven different pan shapes are produced at Twinsburg, for all body styles of all Chrysler cars except the Valiant, Lancer and Imperial. Normally the high-production Plymouth and Dart floor-pan assemblies are produced on the "B" welding line, while any one of the other shapes can be produced on the "A" line.

Changes in the shape of an assembly (from a 122-in. wheelbase station wagon, for example, to a 118-in. wheelbase sedan) can be made in six hours by cranking sections of individual welding fixtures into the required positions. New car configurations can be adapted to the line in an eight-hour shift.

At the extreme end of the T-shaped welding lines, sheet steel is welded into inner and outer rails to make a ladder assembly. At the other end of the T, centre and rear floor pans are welded together.

The rail ladder assemblies, rear and centre floor-pan assemblies meet at the centre and turn in a straight line, to pass through a number of welding

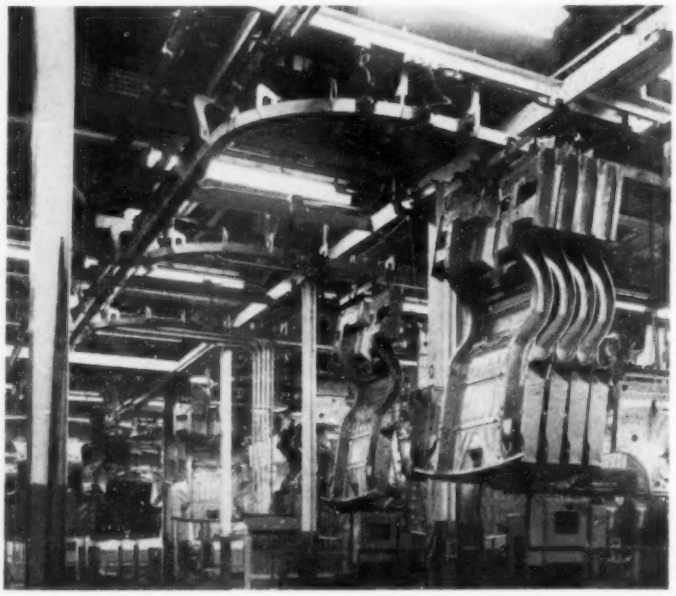
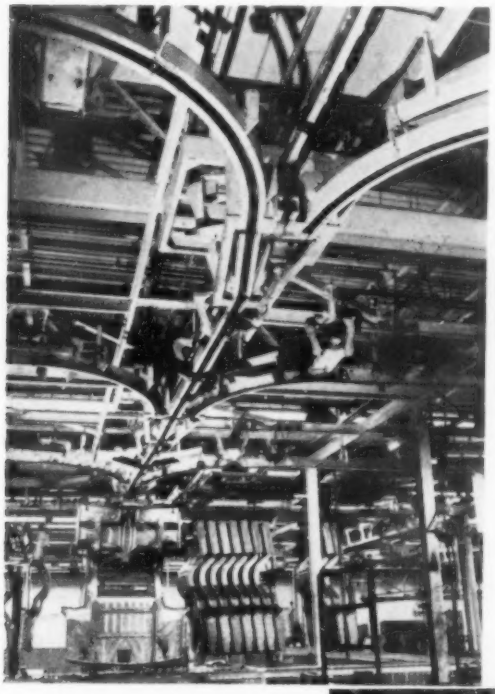


Fig. 4 (right).—Distributing conveyor programmes the floor-pan assemblies equally into three two-station inspection lines. The system is designed so that when any line has a normal storage of four assemblies, that station is dropped out of the programme. When all three lines have a bank of four, half of the production is automatically switched into a storage bank at the pick-up conveyors. These stored assemblies are fed back onto the line automatically after the inspection catches up and empty pusher dogs become available. From each inspection storage bank (free portion of power-and-free system) a manually operated escapement device permits the operator to release one carrier at a time onto a drop-and-turnaround device. At this station the operators inspect one side of the unit and then pass it on to a storage area before the second inspection station, where duplicate equipment permits the next operators to inspect the other side of the assembly. All floor-pan assemblies receive additional arc-spot welds in certain high stress areas

machines for the marriage process. The ladders and pans travel at high speed on large shuttles which move the assemblies from one welding machine to the next.

An electronic scanning pulse, travelling from one welding machine to the next at the rate of 120 millionths of a second, controls all welding operations. This electronic brain controls the



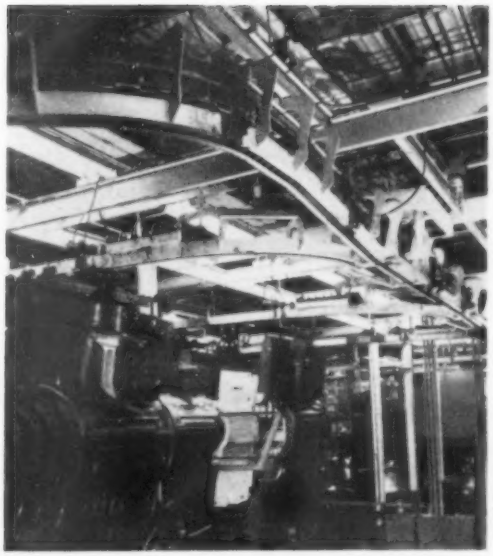


Fig. 5 (left).—From each of six two-station inspection areas at Chrysler Corporation's Ohio Stamping Plant in Twinsburg, Ohio—three areas for each of the two duplicate welding lines making floor-pan assemblies for different models simultaneously—the floor-pan assemblies are fed (intermixed) by a feeding mechanism onto another power-and-free conveyor, through air-operated switches, and distributed automatically to seven areas

Fig. 7 (above).—Floor-pan assemblies are automatically fed into the power-and-free conveyor line as empty trolley pushers arrive, and the assemblies are conveyed to the rack loading area for sorting and shipping

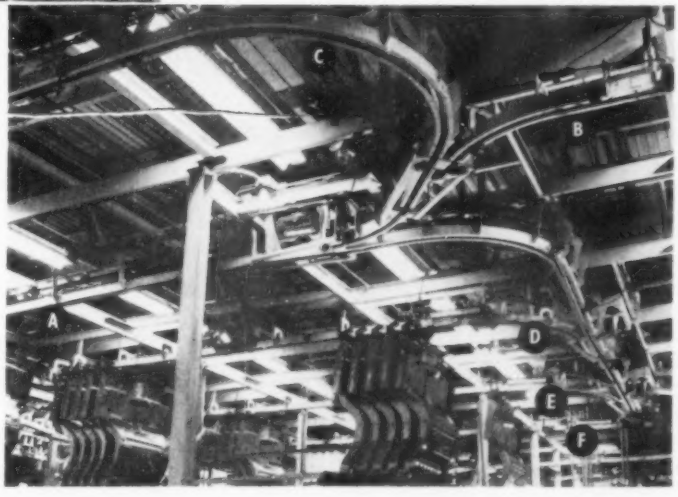


Fig. 6 (right).—Tabbed assemblies are carried on power-and-free conveyor (A) to major repair free line (B). Storage conveyor (C) carries pan assemblies for work areas when storage areas ahead of these areas are filled. In these areas, manually operated escapements permit the operator to release one pan assembly at a time onto a drop-and-turnaround device for work. When the work is completed, the device is raised and unlatched, and the floor pan assembly is moved manually into the pick-up area (D, E and F) and then fed automatically onto the power-and-free conveyor

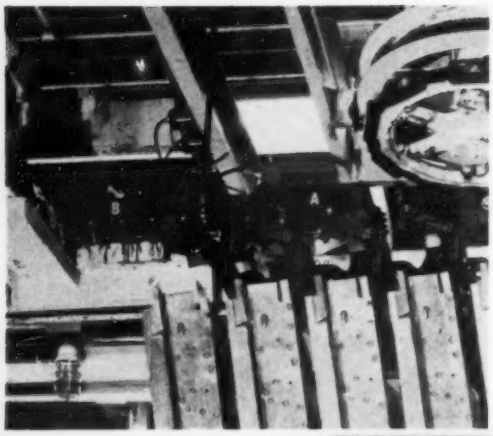


Fig. 8 (above).—Units on storage conveyor are held at air-operated, electrically controlled escapement device (A). Pans can be released into screw feeder (B) to be fed into line

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Fig. 9 (below).—Floor-pan assemblies in work area stop at manually operated escapement (A). The operator releases one assembly at a time, and the lowering device transfers it to low-level track (B)

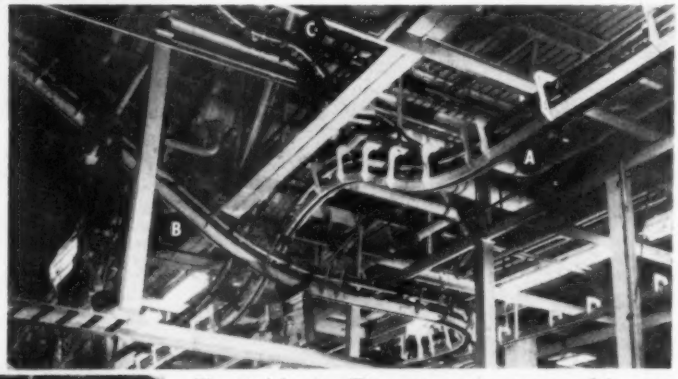
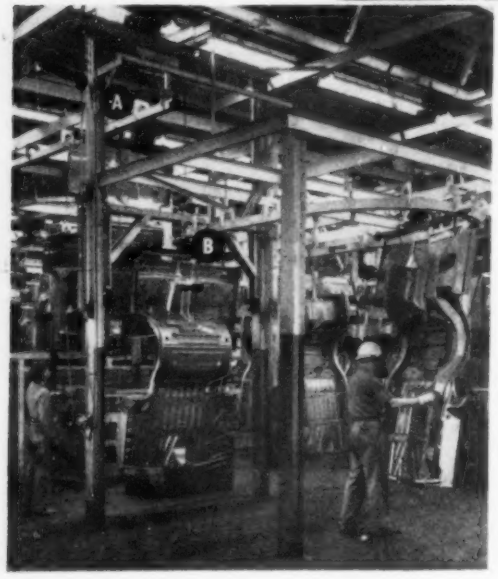


Fig. 10 (above).—The empty carrier, power-and-free conveyor (A), on its way to welding line "A," passes over the power-and-free distributing conveyor (B). The return chains for both conveyors (C) are up in the trusses, completely out of the way



firing in millisecond intervals to each of 24 machines, 32 times a second, so that no two fire at the same time. More than 860 spot welds are made in this manner in forming the rail and floor pan assembly.

The scanner directs the use of 90,000 kilovolt-amperes of energy, the electrical demand of the 24 welding machines. This is equal to 45 million watts or 60,000 h.p. Firing of any two of these welders simultaneously would seriously affect the quality of the weld, because of the excessive voltage drop.

The Link-Belt power-and-free conveyor system is designed for completely automatic operation. Power-and-free conveyors are a combination of powered trolley conveyors and unpowered monorail-type free conveyors. They provide in one integrated conveying system all the advantages of both types of conveyors, coupled with any desired amount of automatic control.

Two sets of track are used, usually suspended one above the other, although a side-by-side track arrangement can also be supplied. The upper track is a structural I-beam and carries the powered trolley conveyor. The lower, or free, track usually consists of two structural channels or angles and carries fourwheel load-carrying trolleys from which carriers are suspended. Load trolleys have two integral pivoted dogs which engage pushers attached to the power conveyor trolleys or chain. Load trolleys are switched to and from adjacent unpowered free tracks on either or both sides of the main power-and-free conveyor while the power conveyor is moving.

The system includes 15 powered trolley conveyors, with common drives serving two or three of the conveyors in some instances. These powered

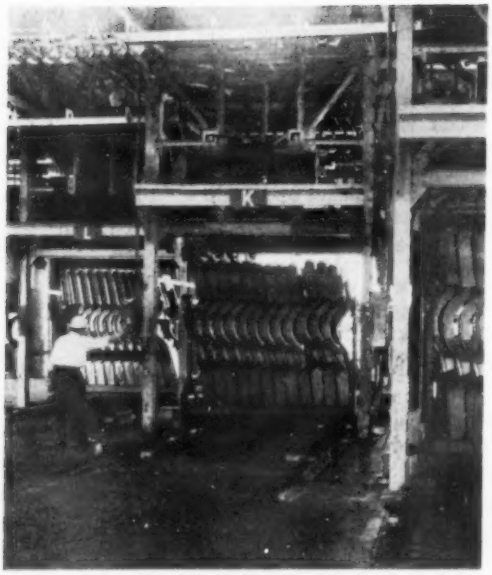


Fig. 11 (left).—The first two of three rack-loading stations for finished floor-pan assemblies load pans from higher capacity welding line; the third loads pans from other line. The two types of assemblies are sorted automatically into proper rack-loading unit as carriers approach each switch-off point. Carriers move by gravity through escapement device that counts out 12 carriers and shuts off. These 12 pans are then pushed as a unit into rack-loading device by a side-finger chain conveyor

conveyors propel unpowered monorail-type trolleys which carry the floor pan assemblies from either of the two resistance welding lines to three inspection areas for each half of the system. The system also conveys empty carriers to and from storage and to the end of each welding line, where they pick up the welded floor pan assemblies.

The free tracks for the unpowered load-carrying trolleys have switches like a railroad track which are

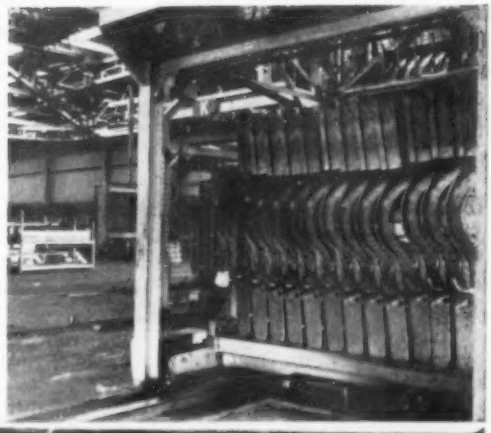


Fig. 12 (top, right).—In rack-loading unit, a clamping and spacing device engages the assemblies, and they are lowered into empty rack which has been brought into proper position by double strand, flat bed roller chain conveyor. Floor conveyor moves loaded rack onto gravity roll conveyor

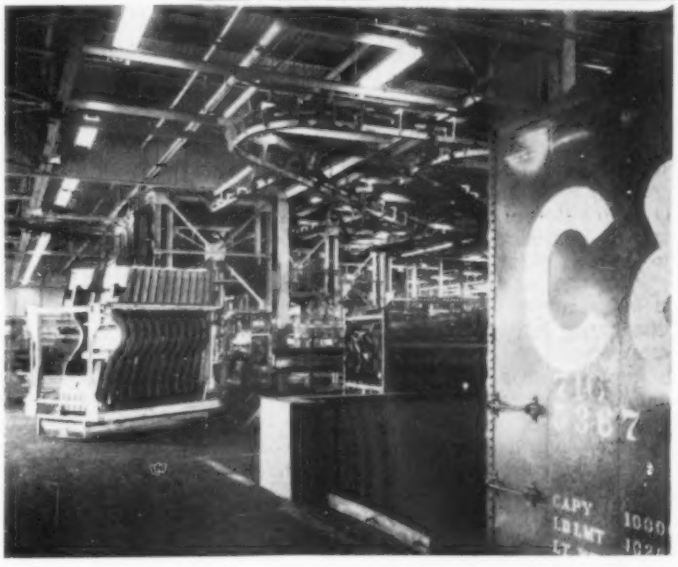


Fig. 13 (right).—Two upper retaining bars are put in place and the loaded rack is taken by fork-lift truck to be loaded into a box car for shipment to one of Chrysler Corporation's automobile assembly plants

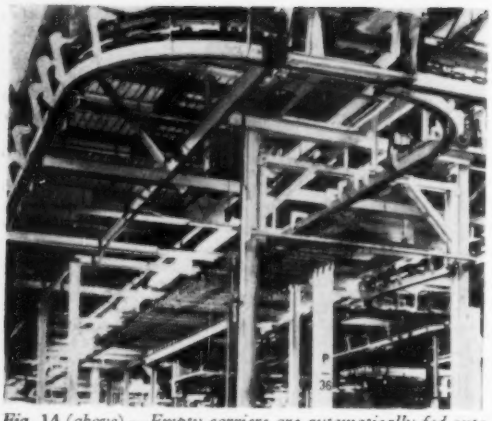


Fig. 14 *(above).—Empty carriers are automatically fed onto power-and-free conveyor and distributed to two welding lines as needed. Excess carriers are switched to storage conveyor*

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Fig. 15 *(right).—Caterpillar drives for long conveyors have brake motors to eliminate backward travel when stopped. Take-up permits removal of one entire pusher-dog increment*

actuated by some 320 limit switches and electrical interlocks. Escapement mechanisms feed the carriers automatically from the free tracks onto the power-and-free conveyor lines.

Built-in Programming

Built-in programming permits the conveyor system to perform many handling operations entirely automatically :

Floor-pan assemblies are fed to any of three inspection lines. When any line has a normal storage of four assemblies, it is dropped from the programme. When all three lines have a bank of four, half of the production is automatically shifted into a storage bank, later to be fed automatically back into the line.

Inspected assemblies are fed automatically from six inspection lines (intermixing two models) and are distributed automatically to any of four work areas to a storage conveyor if the area indicated by tabs on the carrier is loaded to capacity, or directly to the rack-loading area.

Floor-pan assemblies which are held on the storage conveyor are automatically returned to the distributing conveyor for another pass at the four area switches.

Approved floor assemblies are automatically fed onto the conveyor which delivers them to the rack storage area.

Floor-pan assemblies from the two welding lines, which have been intermixed, are separated automatically and delivered to separate rack loading stations—two stations for floor-pan assemblies from the high-capacity line and one for the other line.

Empty carriers are automatically fed into a power-and-free conveyor which distributes them automatically to either welding line as needed or, when not required, to a storage conveyor.

This is but a brief resumé of some of the flexibility which is programmed into this power-and-free conveyor system. Controls have been installed to alter the speeds of some of the conveyors in the system and to shut off certain units when only one of the welding lines is operating.

The high rate of 700 units an hour was established in order to take care of stepped-up production requirements whenever they occur.

The picture sequence and plan drawing trace in greater detail the many steps before an assembly is ready for shipment.

Acknowledgement is made to the Link-Belt Company, Prudential Plaza, Chicago 1, Illinois, U.S.A., and to the Chrysler Corporation, Detroit, 31, Michigan, U.S.A. for permission to publish this article.

INSTITUTION OF METALLURGISTS
Annual Luncheon

THE annual luncheon of the Institution of Metallurgists was held at the Park Lane Hotel, London, W.1, on May 17 last. The toast of "The Institution" was proposed by the principal guest Sir Patrick Linstead, C.B.E., F.R.S., (Rector of The Imperial College of Science and Technology), a reply being given by the President, Dr. N. P. Allen, M.Met., F.R.S. Dr. E. G. West, Senior Vice-President, proposed the toast of "The Guests," to which a reply was given by Sir William Cook, C.B. (U.K. Atomic Energy Authority).

PRODUCTION OF POWER-TRANSFORMER CORES

New Core Plate Cutting Machine at Ferranti Ltd.

A NEW and unique fully automatic core plate cutting machine (Fig. 1) has been installed in the Transformer Department of Ferranti Ltd., Hollinwood, Lancs.

The research work which has been undertaken over a period of several years into the properties and characteristics of cold-rolled grain-oriented steels has resulted in the evolution of new core designs which, in turn, require extremely accurate manufacturing techniques. The new core plate cutting machine produces core laminations from continuous rolls of steel to a degree of accuracy never before achieved.

Until the advent of grain-oriented cold-rolled continuous steel strip, core production was limited by the size of hot-rolled electrical sheet steel which could be supplied by the steel manufacturer, *i.e.* maximum plate size 9 ft. by 3 ft. With the introduction of cold-rolled steel in continuous coils, it soon became apparent that the capacity of machines available would still set a limit on core production.

Ferranti Ltd., therefore, embarked upon a plant development programme with the object of introducing some measure of automation to core plate production to improve the limits to which core plates could be produced and at the same time overcome difficulties in handling.

To handle the continuous coils of steel supplied by the manufacturers, special-purpose rotary guillotines or slitting machines were developed. The purpose of this slitting machine is to reduce the width of the coil of steel to that required for the production of core laminations or plates. The machine consists of a de-coiler, which allows the coil to unwind and pass through the cutting head, where it is slit into strips of the required width. From the rotary cutters the material passes to the re-coiler, where the individual strips are re-wound. This machine can handle coils of up to 3 tons weight and from $3\frac{1}{2}$ in. to 36 in. wide. A maximum of 8 strips can be cut at one set-up and strips down to $1\frac{1}{2}$ in. wide can be produced.

The continuous strip, of correct width, as received from the slitting machine was, until the installation of the new core plate cutting machine referred to above, reduced to the lengths required on conventional guillotine machines with subsequent press operations for the punching of holes and slots and edge grinding to remove burrs caused by the slitting and punching operations. Depending on the design of core, the plates were either

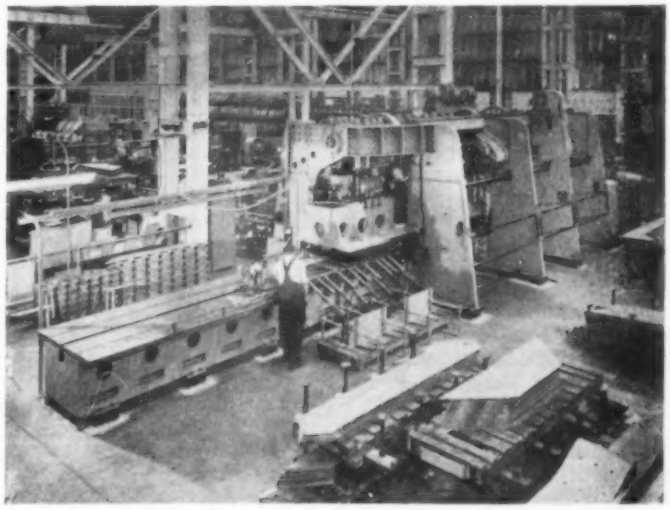


Fig. 1.—Fully automatic transformer core plate cutting machine viewed from the extension bed end showing material in tension just prior to press operation and rejection. The second plate is ejected on the opposite side of the machine

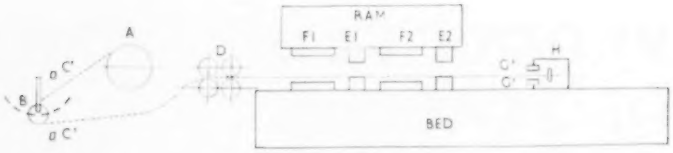


Fig. 2.—Layout of the automatic core plate cutting machine

rectangular or a regular 45 deg. trapezoidal shape.

By this method of production, the limits to which individual plates were produced depended on individual guillotine and press operations working from the same datum point or stop each time.

With the general increase in transformer size, plates of up to 15 ft. long were being required regularly and the handling problems associated with this type of production began to approach the limit of human capability.

The new fully automatic core plate cutting machine combines in one operation the piercing of all holes or slots and the cutting of two plates per cycle of the machine. Provision is also made for grinding of edge burrs, if necessary. All dimensions are related to the theoretical centre line of the strip of material, *i.e.* the centre line of the core. This has the advantage of dividing possible inaccuracies in the width dimensions equally to both sides of the plate, and not to one side only as in the case of guillotine or press production where all measurements were made from one datum edge of the material. The possibility of variations in length dimensions occurring due to human error in the case of guillotine and press production have been eliminated by cutting both ends of each plate and punching all holes and slots in one operation of the machine while the strip of material is in tension.

Fig. 2 shows the layout of this plant with its control equipment, the bed of the press being 30 ft. long and 4 ft. 8 in. wide. The machine is fed automatically to cut laminations two at a time, each 15 ft. by 36 in. wide and a special facility catering for laminations up to 47 in. wide has been incorporated.

The sequence of operations, having set all the tools, end, hole or slot forming, is first to load the de-coiler (A) with a coil of material of the width and grade required. With the machine under hand control, the material is fed round the swinging arm (B) through the feed rolls (D) until the leading edge is beyond the first end forming tool (E_1). The machine is operated by foot control and one set of holes or a slot is pierced by the piercing tools (F_1) and a 45-deg. mitred end, formed by tool (E_1). The piece of scrap material lying beyond (E_1) is removed and the press switched to automatic control.

The automatic sequence is now, feed rolls (D), draw material from the loop between (D) and (A) passing it under the piercing and end forming tools. When the swinging arm (B) is pulled sufficiently far from the at-rest position, contact across the photo-electric cell (C′-C′) is made and the de-coiler (A) operated, thus supplying more material to the feed rolls. As the leading edge of the material interrupts the photo-electric cell (G′-G′) the rate of feed is cut from 200 to ½ ft. per min. until the leading edge hits a microswitch in the hydro-pneumatic press unit (H), when the unit operates and punches a small anchor hole in the material, the punch remaining through the material. The action of punching the anchor hole immediately opens one pair of the main feed rolls (D) and causes the other pair to reverse, thereby pulling out any ripples there may have been in the material.

This slow tensioning of the material continues until the electric clutch, through which the rolls are driven, starts to slip, when a hold-down ram in the feed roll unit (D) operates and holds the material in the tensioned condition. The reversing rolls return to the disengaged position and the ram operates, cutting and piercing two complete plates. As the ram rises all side stops are lowered and the piercing tool in the hydro-pneumatic press unit (H) is withdrawn, thus setting in operation the ejection mechanism which ejects one complete plate to the back and the other to the front of the machine where they are automatically stacked on pallets. As ejection is completed, this cycle is repeated automatically.

The machine is equipped with modern and completely adequate safety devices at all stages of operation.

Special features of interest in this machine are:—

Overall length of plant ..	60 ft.
Overall width of plant ..	4 ft. 8 in. bed
Overall height of plant ..	12 ft.
Method of control ..	Electronic-pneumatic-hydraulic
Weight of moving parts ..	10 tons + 3 tons for tools
Total weight	60 tons
Weight of end forming ..	Two
Range in plate size ..	From 15 ft. to 2½ ft. centre line length, from 36 in. wide to 5 in. wide
Maximum number of holes	Unlimited
Maximum number of rows of holes	Unlimited

(*Continued in page* 457)

An Introduction to the

THEORY AND PRACTICE OF FLAT ROLLING—9

By the late C. W. STARLING, B.Eng., A.M.I.Mech.E.

(*Series continued from page 252, April, 1961 issue*)

CONTROL OF PHYSICAL PROPERTIES

IN this chapter "physical properties" refers particularly to the shape, width, thickness, length and flatness of the rolled product, as opposed to the metallurgical properties which are discussed in the next chapter, although there is bound to be some overlap between them.

In rolling tinplate, sheet, strip or plates, the following are the common properties which are of particular importance :—

1. Width.
2. Gauge, both across and from end to end of the strip or sheet.
3. Length.
4. Cross-section.
5. Flatness.
6. Surface finish.

As most flat products are now produced from a semi-continuous or continuous strip mill or plate mill, particular reference will be made to this type of mill. Before considering the mill, however, some discussion of the previous history of the metal to be rolled is necessary.

It is true to say that for the highest standard of finished product, quality control starts in the melting shop, where it is essential to make a homogeneous ingot with no holes, cracks or segregation or dirt inclusions. The design of the ingot mould is an important feature and is usually a result of collaboration between mill management, metallurgical department and possibly the works research department. The chief factors considered in the design of the ingot mould are :—

Ease of stripping.

Minimum reduction to give the correct slab size and yet give sufficient work on the slab to make it as near homogeneous as possible.

Calculated reductions to give the maximum rate of rolling in the slabbing mill.

The correct size to give a finished cropped slab size which can be cut without waste into standard slab lengths.

In order to fulfil the first requirement, ingot moulds are designed with a taper in the thickness and sometimes in width also. A taper of 2 in. in thickness from end to end of a large ingot is common, but it is not unknown for tapers as high as 4 in. to be used. This taper in the ingot will cause some degree of taper in the finished slab, the magnitude depending on the roll-gap transfer function, which will vary with the grade of steel and the temperature. In general, with the smaller ingot taper mentioned and the relatively stiff slabbing mills normally used, the final taper on the slab will be only of academic interest.

More important than this is to ensure that the temperature throughout the ingot is constant. This is done by keeping track times (the time from teeming to charging in the soaking pits) as short as possible and holding the ingot in the soaking pit long enough to obtain an even temperature throughout. Table I shows typical soaking times required for various track times on 15-ton ingots, although they will obviously vary from mill to mill, depending on the design of the pits. Any relatively cool spot in the ingot will mean a higher yield stress at that point and correspondingly greater spring of the mill, giving a slightly heavier slab over the cooler areas.

Track Time (Teeming to Charging)	Total Firing Time
2½ hours	3¼ hours
3 hours	3¾ hours
3½ hours	5 hours
4 hours	6 hours
4½ hours	7 hours
5 hours	8 hours
cold	15 hours

It has been mentioned earlier that in order to obtain an accurate slab shape, it is essential to turn the ingot on edge at least twice during rolling and by taking a sufficient number of passes, it is possible to obtain accurate width and gauge. In a normal slabbing mill, however, it is rare to obtain good square corners. The modern universal mill with its vertical rolls to control spread, gives a much better performance in this respect. Unfortunately, the capital and running costs of a modern slabbing

mill are so high that it is essential to obtain maximum output and in order to do this, the number of passes are reduced to a minimum. It is not unusual, therefore, to subordinate top-quality slab shape to output with the knowledge that an acceptable slab can be rolled into good shape in the strip mill. Although all modern mills are equipped with screw position indicators to enable the rollerman to obtain the correct slab size, it is essential that periodically the slab should be measured after cooling, so that the rollerman will be able to adjust his allowance for mill spring and shrinkage, as necessary. The usual allowance is to take $\frac{1}{8}$ in. shrinkage per foot of width at slabbing-mill temperatures.

In order to obtain high-quality finished products rolled slabs are usually cooled and surface faults rectified before sending them on to the strip mill, although on occasions suitable slabs may be sent straight from the slabbing mill. It is becoming quite common to install an automatic scarfing machine consisting of a large number of oxygen jets which burn a thin skin from the slab and remove the surface defects. There is still some controversy as to whether the advantage to be gained from this will outweigh the cost of the machine and the loss of yield, which can be as much as 2 per cent, and the most common practice is still to cool off the slab and inspect it in the slab yard with spot scarfing being carried out manually with hand torches. Small individual defects can be removed quickly by hand torches and even quite large areas can be washed over quickly. At this stage the inspector must decide whether to remove all defects, which may include deep cracks. If a slab is gouged out to remove a crack completely, the resulting change in slab section may be sufficient to cause errors in gauge and width. There is some lateral flow in hot rolling, but this is usually insufficient to compensate for any major change in slab section. For example, if an 8-in. thick slab has a crack removed, necessitating a reduction in thickness of 1 in. over an area measuring say 6 in. × 3 in., it will be seen that when the slab is rolled down, the length of 6 in. could well extend to 50 ft. The gauge will then be a little less than required for a strip several inches wide and 50 ft. long. This will be made clearer by reference to Fig. 144. Similarly, if a deep gouge is taken down the side of the slab, as shown in Fig. 145, this again will roll out to a considerable length which will be narrower than the rest of the coil.

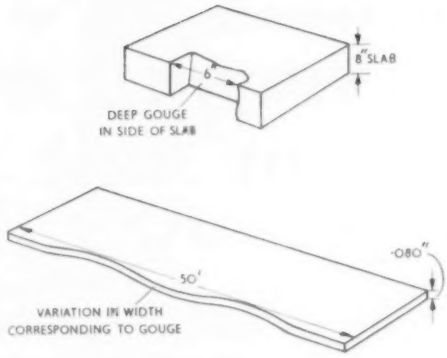
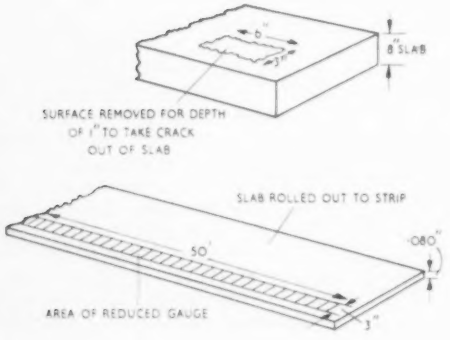


Fig. 145

Having inspected and cleaned up the slabs, they are charged into a reheating furnace to bring them up to temperature for final rolling. As in the case of the soaking pits, it is essential that the heat is uniform throughout the slab, as any cool areas will affect the finished gauge. It is unfortunate that in a continuous slab furnace, skids must be supplied for the slabs to slide on through the furnace. As many mills to-day roll electrical grades of silicon steel which require extremely high temperatures in the slab furnace, it is essential that these skids be adequately cooled and even with furnaces dealing only with mild steel, the temperatures are so high that uncooled skids would have a very short working life. As the slabs pass through the furnace, therefore, for most of the time they are sliding along and in contact with, a number of skids, each of which is water-cooled and is extracting heat from the slab. The slab leaving the reheat furnace then has a temperature profile corresponding to the number of skids, as shown in Fig. 146. When passing through the strip mill the gauge will increase a little as each cool region passes through the mill, due to the higher yield stress and greater mill spring. The effect of the cool areas on width

Fig. 144



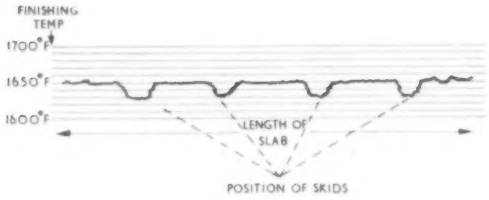


Fig. 146

will be less, but can be appreciable when in the finishing train as there will be a change in tension due to change in gauge at the cool spots.

In passing through the roughing mills, it is essential to keep strict control of width. Some considerable correction to gauge can be made in the finishing train, whereas it is very difficult to control width when the strip is thin, as any attempt to roll the edges will result in bending over the edges or buckling the strip, causing a mill pinch. This is not to say however that gauge is unimportant in the roughing mills and every effort must be made to obtain a uniform thin slab of the required gauge and width at the delay table, before entering the finishing mill. This is the critical stage in the production of flat products, as many width and shape defects cannot be removed in subsequent processes. The control of the finishing stands will, therefore, be discussed at some length and each of the six factors listed at the beginning of the chapter will be taken in turn.

1. Width

It is well known that in hot rolling, the material " spreads " due to lateral flow in the roll gap. This spread varies with the type of material being rolled and the temperature, but in most cases is greater on the thick slab than on thinner strip. In order to obtain the correct finished width, the slab size is made a little under the required strip width, the difference being taken up by the spread. The amount of spread is controlled in the roughing stands by vertical edger rolls, but the reduction in width which can be obtained by these becomes progressively less as the slab becomes thinner and an overwidth slab will never make the correct sheet width. Having obtained the correct width at the delay table, there is a serious possibility of reducing the width in the finishing stands by applying tension between stands. The mills in the finishing train are set up with matching screw settings and speeds and any change in screw setting on one mill will cause a change in backward and forward slip, giving a change in the tension between this mill and adjacent stands. A very accurate control of speed is required, as if the tension becomes zero and a loop begins to form, it will rapidly get out of control, double over and cause a cobble. On the other hand if anything more than a nominal tension is applied to the strip, there will be a tendency to creep, followed by necking down in width and gauge. Experiments have shown that even with a moderate tension, it is possible to neck down in width as much as three inches in a 40-in. wide strip ; this being accompanied by a similar percentage reduction in gauge. It is usual when operating the finishing train in a strip mill to use one mill as a " pivot." This particular stand is set out to a constant speed, which governs the overall speed of the mill and any speed variations, due to change in hardness of the strip, or changes in screw settings, take place forwards or backwards from the " pivot " mill. Obviously, if the stand after the " pivot " stand has to be speeded up for one of the above reasons, it will be necessary to increase each subsequent stand by a similar amount.

This speed control is one of the important features in operating a strip mill as once the strip has necked down in width, it is impossible to apply any further correction to obtain the correct width.

The universal practice in producing cold-reduced strip is to trim the width accurately at some stage in the process by rotary shears. This, however, does not imply that width tolerance is unimportant in a strip mill, as any over width results in a yield loss costing many thousands of pounds per week in a high production mill, whereas any under width will mean that the material does not make the order for which it was intended and will require re-routing, necessitating delays and late delivery to the customer. In applying this under width order to another customer's order, it is probable that it will have to be trimmed narrower, with again a loss in yield.

2. Gauge

There are probably more technical papers on the subject of gauge control than on any other rolling subject and it is not proposed to enter into a very detailed discussion of rolling theory as applied to gauge. The following are some of the major factors which influence gauge in the hot-strip mill :—

(*a*) Uniform temperature throughout the material being rolled.
(*b*) Uniform chemical analysis with no segregation and dirt inclusions.
(*c*) Uniform thickness of slab entering the mill.
(*d*) Uniform width of slab entering the mill.
(*e*) Correct screw settings on each stand.
(*f*) Correct speeds throughout the mill train giving correct tension control.
(*g*) Constant roll temperature.
(*h*) Constant mill housing temperatures.
(*i*) Correct ground rolls and no excessive roll wear.

When a slab is brought up to the strip mill, the rollerman has no control over its analysis and condition, but he can ensure that it is in the slab furnace sufficiently long to give a uniform temperature. The width and thickness of the slab is outside his control, but he must use the roughing mills to give the required width and thickness at the delay table before entering the finishing mill train. If the slab has been brought through the roughing mills at the correct speed, the temperature at the delay table should be that required, but if too high, the rollerman can hold it for a time at the expense of output. If it is allowed to go forward a little above temperature, the mill screw setting must be adjusted to allow for this. In general, the screws in each stand are set to the value which has been found by experience to be suitable for the width being rolled, giving the required gauge from the scheduled slab thickness with slight modifications for slab temperature and type of steel. The usual technique is to set up each mill to give fairly constant reductions through the finishing train, except for the last stand which is used as a shaping stand. Although there are many hot-rolling theories which claim to give an accurate calculation of rolling load and torque, it has not yet been possible to predict the correct screw setting for a hot strip mill with any degree of accuracy by calculation. In obtaining correct gauge, it is essential that the early stands be set up accurately as while the slab is relatively thick and hot, a small change in screw position will make an appreciable change in gauge. At the penultimate stand when the strip is thin, a substantial screw change is required to make any change in gauge. For example, when rolling 50-in. strip to a gauge of 0.074 in., it has been found that a screw movement of 0.040 in. gives a barely detectable change in gauge. This is a very useful property, as at the last stand quite large variations in screw setting can be made without affecting the gauge and this will be mentioned under the heading of " Control of Cross Section and Flatness."

Having set up the mill for a constant gauge, in the past it has been the practice to run the coil through and measure it with a micrometer after coiling. It is now becoming universal to have an X-ray gauge just after the exit of the last stand which will give a continuous recording of thickness and allow changes to be made as the slab is passing through the mill.

The control of speed is most important and very closely related to the screw setting. The speeds are set up by experience and adjusted as soon as the bar is in the mills to ensure that the strip is just held tight between stands without applying excessive tension. Any tension will cause a slight thinning of the strip together with a narrowing in width due to creep, and will also affect the roll load and gauge out of the previous mill.

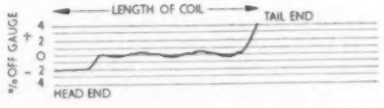
Fig. 147

Once the mill has reached its normal operating temperature after a shut-down, the roll and housing temperatures remain fairly constant. During the warming-up period, however, constant small screw adjustments will be required to compensate for expansion of the housing and expansion of the rolls.

The rolls must be ground truly circular, as any ovality or eccentricity from the back-up rolls causes a cyclical variation in gauge, as seen in the chart recording, Fig. 147, which is typical of a large sheet mill with high-quality roll grinding.

A major difficulty in a continuous strip mill is the control of constant gauge from end to end of the coil. In order to obtain high production, the heaviest possible slabs are used, bearing in mind the maximum length which will go in the slab furnace and the heaviest practical drafting on the mills. It is then difficult to maintain a constant temperature throughout the length of a coil, as the leading end of the strip is travelling at speeds up to 2,000 ft. per min., whereas the tail end is travelling at only one or two hundred ft. per min. as it enters the last stand of the finishing train. During the time taken to roll one slab, the back-end will cool by radiation sufficiently to cause an increase in yield stress and hence a heavier gauge as it passes through the mill. In addition to this, there is a reduction in gauge on the first few feet of a coil, as the impact on entering the mill causes an elastic shock wave in the mill housing, giving a slightly heavier reduction than would be expected from the screw setting, until the shock wave is damped down. There will also be a change in gauge at the end of a coil due to variations in tension, as the tail end leaves each successive stand. A typical gauge profile of a hot-mill coil is shown in Fig. 148. From time to time attempts have been made to produce a more consistent gauge from end to end, but so far with little success. It is unlikely that any control will reduce the thinning of the front end due to the shock wave, but this is not of very great importance, as it is usually only a distance of 20 or 30 ft. and some of this will be removed at the pickle line in any case when welding coils together. Attempts have been made, both

Fig. 148



automatically and manually, to adjust the screw settings continuously during the passage of a coil to compensate for the steady reduction in temperature and increase in yield stress. It is possible that this could be done on a relatively low production mill, but when slabs are rolled nose to tail, with only a few feet separating them, it is not possible with conventional screw-down gears to screw down steadily throughout the coil, then raise the screws quickly enough to be in the correct setting for the next coil. It may be that eventually hydraulic control of the load will be built into mills, in which case it may be possible to apply this correction. Differential heating in the slab furnace has been used to give a hotter tail end of the slab. This method is still in use in some mills, but is not very successful, probably because the hotter part of the slab loses heat by radiation at a greater rate than the cooler part and the temperature gradient from end to end at the finishing mill will not be greatly improved. In general, the practice is to run the mill as fast as possible and so reduce to a minimum the time of each bar in the mill, and hence the loss of heat due to radiation.

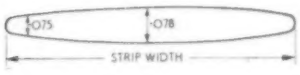
3. Length

On the hot-strip mill length is usually of little importance to the rollerman. All slab sizes are calculated by the scheduling office and each slab is rolled into a complete coil. When rolling flat plate, however, a slab is sometimes cut into several pieces by means of a flying shear after the finishing mill. This procedure is now falling out of use for a continuous strip mill, as it is necessary to run at a reduced speed to ensure shearing to the correct length.

4. Cross-Section

Although it is possible to obtain a perfectly rectangular cross-section, in practice it will be very difficult to maintain this for different widths and gauges without excessive roll changes. In any case, this is not desirable, as subsequent processes require a slight " crown " on the strip or sheet, particularly in the wider sheets. The method of cambering rolls to compensate for roll bending has already been discussed and in practice it is usual to make the camber slightly less than that which would be required to give a rectangular cross-section and so produce a slight " crown " on the sheet or strip. The cambers required for various widths and gauges are quickly found by experience and small variations are controlled by water cooling of parts of the roll. A good cross-section of a sheet from

Fig. 149



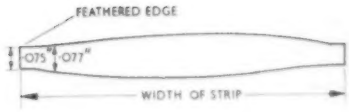


Fig. 150

the hot mill is shown in Fig. 149 and it will be seen that there is a slight unavoidable edge thinning due to roll flattening, as explained in Chapter 4. Although this slight edge thinning has little effect on subsequent cold reduction, any excess thinning or " feather edge " is most serious. If the cross-section is as shown in Fig. 150, it will be seen that during cold reduction the rolls will barely touch the edges and in reducing the major part of the sheet, the edges will be stretched and cracked. This condition can be obtained if a relatively large tonnage of a fixed width is rolled, causing the rolls to wear over this width, followed by the rolling of a slightly wider sheet. Alternatively, it can be obtained along one edge only if the sheet moves a little off centre. This is one of the reasons why a hot strip mill is scheduled to roll from maximum width to minimum, followed by a roll change before opening out wider again.

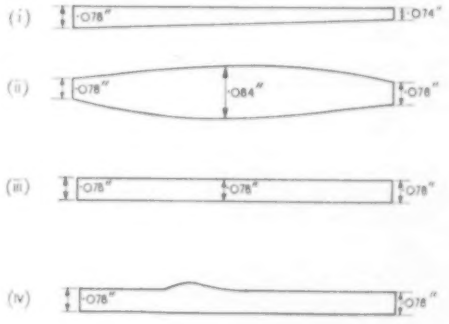
Other common faults in cross section are shown in Fig. 151. A taper can be caused by incorrect screw setting from side to side or overheating of one side of the rolls. The ridges can be caused by blockage of a water jet, giving a ridge of heavy wear on the roll, due to abrasion by scale.

5. Flatness

Sheet or strip leaving a continuous strip mill must obviously be as flat as possible and with a consistent cross-section.

The last stand of the finishing train is used for shape correction, with very little reduction in gauge. When properly used, it is possible to reduce or

Fig. 151



remove any ripples left from the previous stands, as a considerable variation in screw setting and roll load can be obtained on this stand, with little effect on gauge and this is used to vary the roll bending and obtain a sheet as near flat as possible. Unless the edge or centre ripples from a hot mill are particularly serious, it is usually possible, though not desirable, to obtain an acceptable flatness after cold reduction by adjustment of cambers on the cold mill. On occasions, however, a narrow band only a few inches wide may ripple in the hot mill and this is virtually impossible to remove at a later stage. A close watch must, therefore, be kept for this particular fault on a strip mill and it can usually be traced to local overheating of a roll, due to the failure of a cooling jet, or the build-up of a ridge of scale on a roll, due to failure of a scale removal jet.

6. Surface Finish

A properly planned schedule of roll changing will ensure an excellent surface finish from a strip mill. In fact, the quality is so high that many components hitherto made from cold rolled sheet or strip are now being made from the cheaper hot rolled product. An average round between work roll changes on a wide strip mill is approximately 3,000 tons and this will include many widths from maximum to minimum, the absolute maximum to be rolled on any given width being 300/400 tons. The rolls begin to show signs of craze cracking very quickly after starting work and sufficient cooling water must be applied to ensure that the cracking does not spread and deepen, so causing surface marking on the sheet. It has been found that the first two stands in the finishing train roughen up much more quickly than the remainder and to maintain the best possible surface finish, it is usual to change the rolls in the first two mills half-way through each round.

Having arranged the roll changes to give an excellent sheet surface, it is essential to ensure that scale is not rolled into the surface. There are two definite types of scale pattern, one due to a blocked scale removal jet giving a heavy streak of rolled-in scale right through the coil and the other due to very small flecks of scale being rolled in all over the surface. The first type of scale is easy to see and prevent, but fleck scale all over the surface is much more insidious and is often difficult to see before pickling. Constant attention to cooling water and scale removal water is required and only top quality cleaned and filtered water can be used.

There are many other intermittent surface defects, some of which are metallurgical and others due to simple causes, such as guides tearing slivers from the edge of the strip, which are rolled into the surface by subsequent mills or pinch rolls. The highest quality of surface finish can only be obtained by constant attention to detail and high standards of cleanliness.

After leaving the hot-strip mill, the hot-rolled coils are either processed and sold as hot-rolled sheet and plates or sent for further cold reduction. This involves many processes, such as continuous pickling, uncoiling, shearing and levelling, all of which affect the physical properties of the material, but these subsidiary processes are outside the scope of this book and further discussion will refer only to cold reduction and temper rolling.

Taking again the six physical properties in the order listed, with reference to the cold-reduction mill :—

1. *Width*

At the cold-reduction mill there is no control of width, as there is virtually no lateral flow in cold rolling.

2. *Gauge*

Probably the most common cause of rejections in cold-rolled sheet is " off-gauge " and as the tendency is to decrease gauge tolerances, accurate gauge control is of the utmost importance. Although there are still a great many reversing mills in use, the modern tendency is to use three-, four- or five-stand tandem mills for high-production rolling, even for narrow strip. In a tandem mill, of course, the coil passes through only once and gauge must be obtained as soon as the end of the coil is taken up on the tension reel and the mill accelerated. For many years the Flying Micrometer, consisting of a pair of hardened steel wheels running on the strip, has been the standard instrument for measuring gauge, but the fact that it operates by contact with the strip brings in several disadvantages and the modern tendency is to use radiation gauges which operate without contact.

In a tandem mill, any change in screw setting or speed at any point involves a series of changes right through the mill and complicated mathematical formulae have been proposed to calculate the changes which occur. In practice, the rollerman sets each stand load and speed by experience and if there is no continuous measuring gauge after stand one, the outgoing gauge is often checked with a hand micrometer before threading the subsequent mills. As the coil is threaded into each stand, the operator adjusts the mill speed to obtain the required inter-stand tension and when the coil end reaches the reel, adjustments to gauge are already being made to ensure the least possible length of coil off gauge. In general, the final gauge reading is shown on a dial at stand one and the rollhand does most of the gauge correction from this stand, before the material work-hardens. The final correction to gauge is then made on the last stand, although as on the hot mill, this is used primarily as a shaping stand.

The rollhand on each stand is constantly adjusting the stand speed to maintain constant tension between

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(*Continued from page* 456)

each stand, as they will tend to fluctuate as the screws are adjusted. Sometimes, however, it is found more convenient to obtain small changes in gauge by variations in tension, as small adjustments can be obtained almost instantaneously by means of speed control of the mill, whereas the sequence of contactors operating screwdown motors, may require a lag of from one to two seconds to make a change. If this technique is used, tension changes should be followed by a screw correction to ensure that the tension remains within narrow limits.

The principle of the BISRA Automatic Gauge Control has been described and this is working successfully on many reversing mills. There are, however, many problems associated with automatic gauge control on a tandem mill and although considerable progress has been made, it cannot yet be said that it is completely satisfactory. It appears that the solution will be to have one automatic gauge control on the first mill to smooth out variations in gauge from the hot mill and a second system on the last stand to give a final correction. This will, of course, require a fairly complicated system of tension control and the problem will be to obtain stable conditions for any mill setting and rolling schedule.

3. *Length*

The length of a finished sheet is obtained at the cut-up line and is outside the control of the mill operator.

4. *Cross-section*

As already stated there is virtually no lateral flow in cold rolling and the cross-section obtained depends to a great extent on the shape of the hot band from the strip mill. Any " crown " existing in the strip from the hot mill, will persist after cold rolling, but the increased thickness in the centre of the strip will be reduced in proportion to the reduction in the cold mill. It is possible to reduce it a little more if required, but this can only be done at expense of flatness of the finished rolled strip.

Again there will be the typical slight edge thinning, due to flattening of the work rolls, as discussed earlier.

5. *Flatness*

The problem of obtaining a flat strip is very similar to that of the hot-strip mill. The roll cambers must be selected to give a constant reduction across the strip, making allowance for the fact that there will already be a camber in the strip, and water jets are used for final control. Again the last stand is used chiefly for shaping and the roll load is adjusted to give the correct roll bending for the shape of the strip entering. In cold rolling, it is possible to apply heavy tensions at the reel and any slight fullness at the middle or edges of the strip can sometimes be pulled out to give the impression of flatness. It is not a good practice to rely on tension to obtain flatness as this brings in many problems in later processes and the aim should be to obtain the flatness of sheet required with the minimum of tension.

(*Series to be concluded.*)

Production of Power-Transformer Cores

(*Continued from page* 450)

Range in hole sizes ..	$\frac{7}{8}$ in. — 2 in. diameter
Slot size	$2\frac{1}{4}$ in. × $12\frac{3}{4}$ in. one per plate
Weight of end forming tools	$1\frac{1}{4}$ tons each
Number of plates per hour	360 to 480

The plant has been in production since July, 1960 and has achieved the original objectives of producing core laminations to a higher degree of accuracy than previously, resulting in an increase in core efficiency.

Core Plate Annealing

One of the important requirements of cores built of cold rolled steel is to provide careful annealing of the laminations to relieve the stresses set up in the material during the cutting and punching processes.

The continuous annealing plant installed in 1957 is another indication of the determination of Ferranti Ltd. to use this material as efficiently as possible.

The conveyor type stress relief annealing furnace which is 130 ft. long and has an output of half-ton-an-hour has many advantages over conventional batch type furnaces. The annealing operation is carried out in an atmosphere of nitrogen, satisfactory annealing being assured by strict control over the operation of the plant and by regular checking of annealed samples for iron loss by the Epstein Square method. With the continuous-belt type furnace the temperature gradient across a lamination is lower due to the exposed area of the charge being relatively greater and the heat transfer predominantly normal to the laminations. This results in a shorter annealing cycle and consequently reduced risk of contamination from the annealing atmosphere.

Core Plate Insulining

The core material as supplied by the manufacturers in coils is insulated on both sides with a very thin anneal-proof insulating coating applied by a special thermo-chemical process. After annealing, one side of each lamination is further treated with Insuline (Kaolin plus binder) in a modern plant to a controlled thickness.

Bedford Cabs

(*Continued from page* 442)

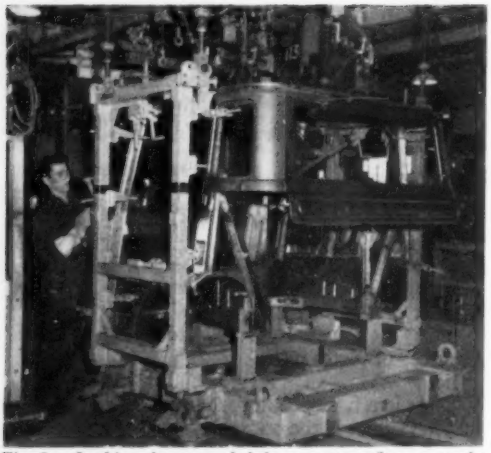


Fig. 3.—Locking the suspended door aperture fixtures to the cab jig truck takes a few seconds. The three major units, floor, back and front end assemblies, are positively locked in the fixture ready for welding

cab-door flanging dies were successfully introduced to ensure dimensional accuracy. The general design of the cab structure has played an important part in simplifying, to some extent, the die design, and the assembly problems and high-quality tooling giving first-class pressed panels has been achieved at a minimum cost.

The cab build conveyor is a long, narrow circuit approximately 380 ft. in length; 19 wheeled jig-trucks, precision-built and weighing just 1 ton each are pulled around this circuit by a floor chain and peg conveyor.

The first four stations on the conveyor are served by a pair of overhead monorails on which are carried four pairs of door aperture " gate " fixtures. These precision-built fixtures lock on to the jig-trucks by means of locating posts and foot-operated butterfly clamps. In this way an exceptionally good and consistent fit of door is obtained, as the cab underbody, rear end and front end sub-assemblies are keyed to the door aperture fixtures.

The new spot-welding guns, 155 in number, are all of a new lightweight pattern designed and made in the body jig shop. They have electronically controlled pressure and weld-timing sequences which ensure consistently sound spot welds. Further savings in weight of the guns have been made by using transparent PVC nylon-reinforced tubing for the water and air connections.

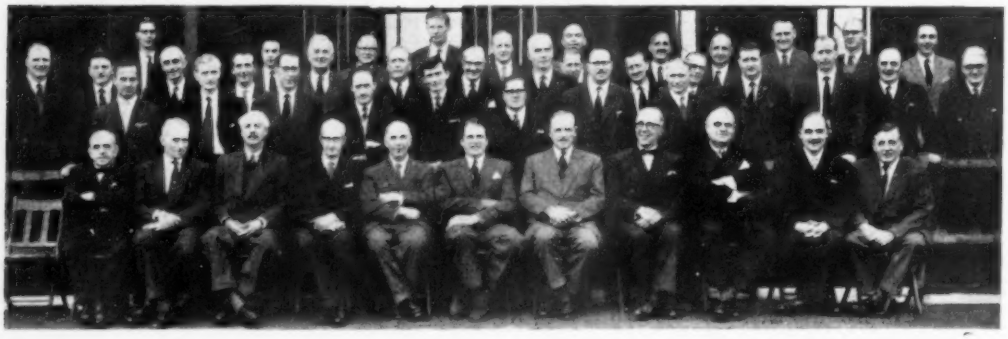
One of the effects of all this attention to detail is that costly hand metal-finishing processes are reduced to essentials. Neat and accurate alignment of abutting edges and flanges reduces puddle-soldering to negligible proportions.

During sub-assembly, several of the joints are sealed against water and dust entry into the cab. These operations are followed at a later stage in the manufacture of the cab, by further rust-prevention and joint sealing processes which parallel those used for sealing passenger car bodies.

OVER thirty executives of companies belonging to the British Power Press Manufacturers' Association were entertained at Wakefield, Yorkshire, on Thursday, May 4, by Joseph Rhodes and Sons Ltd., manufacturers of sheet metal working machinery, power presses, hydraulic press brakes and shearing machines.

After lunch at the Monk Fryston Hall, the afternoon was spent touring the company's works and also the adjoining works of an associate company, Slater and Crabtree Ltd., makers of press tools, die-sets and dies, jigs and fixtures.

The central figure in the front row of the photograph, taken on the premises of Joseph Rhodes, is Mr. Henry D. Challen, Chairman of the Association. On his left is Mr. W. Stanley Rhodes, Chairman of Joseph Rhodes and Sons Ltd. and a member of Council of the Association. On Mr. Challen's right is Mr. C. E. Rockwell, Managing Director of Rockwell Machine Tool Co. Ltd., and a member of Council of the Association, and next to him, Mr. E. C. Seed, Chief Engineer and Sales Manager of Cowlishaw, Walker and Co. Ltd., Vice-Chairman of the Association.



INSTITUTE OF SHEET METAL ENGINEERING

Annual General Meeting

THE Sixteenth Annual General Meeting of the Institute was held at the Connaught Rooms, London, W.C.2, on May 18 last, with Mr. A. E. Gilbert, Chairman of Council, in the Chair. The first two items were the formal adoption of the Minutes of the previous A.G.M. and of the accounts for the year ended December 31, 1960. The annual report of the Council was then presented by the Chairman who said that the year under review had been one of continued expansion and progress. Many long months of protracted negotiations had culminated at the end of the year in the incorporation of the Institute as a limited liability Company, limited by guarantee, with a licence granted by the Board of Trade to dispense with the use of the word " Limited " in the title of the Company in recognition of its technical and non-profit making status. The Sixteenth Annual General Meeting of the Institute would therefore be the last of the old unincorporated body and next year would be held the first Annual General Meeting of the new incorporated Society. The effect of change was purely a financial and administrative one, which resulted in the liability of members being limited in the event of the Institute suffering any major financial set-back and it also made it possible for the Institute to seek exemption from liability to pay Income Tax on any surpluses which might arise.

Membership continued to grow at a steady, although not very rapid rate, a net increase of fifty members in various grades being recorded during the year. On the other hand the Institute was unfortunate in losing certain outstanding personalities, who, up to their untimely and regretted deaths, had played an important part in fostering and furthering the aims and activities of the Institute. Mr. Barrington Hooper, C.B.E., who died last September, was a founder Vice-President, to whose energy, enthusiasm and active support the successful inauguration of the Institute in 1945 was in very large measure due. Mr. Gerald Murray, who died in June, after a long illness, borne with great courage, had pioneered the setting up of the British Deep Drawing Research Group as a Group within the Institute, and had served as Chairman of the Group from its inception, until shortly before his death. Here again the achievements of the Group during the short time that it had been in existence owed a great deal to the wide experience and devoted interest which Mr. Murray had brought to its administration. The Chairman also referred to the regretted death of Mr. Richard Kirchner, a past Chairman of Council, greatly valued for his loyal support and wise guidance, who lost his life in tragic circumstances only a few weeks previously.

On the technical front the Chairman said that the Institute could fairly claim a most successful year. In May, a party of some 30 members of the Deep Drawing Research Group attended an International Colloquium in Paris organized jointly by the International Deep Drawing Research Group and the French Metallurgical Society at which several members of the Group presented papers. Shortly after the meeting the Secretary of the International Group, Dr. S. Garber, had found it necessary to relinquish his office on taking up an academic post in Canada, and Mr. John Hooper, Hon. Secretary of I.S.M.E. had been appointed his successor. On taking up the appointment, Mr. Hooper had resigned as Secretary of the British Deep Drawing Research Group in which position he had been succeeded by Mr. Roger Pearce, chief metallurgist of the Pressed Steel Co. Ltd.

In October a party of members had taken part in a seven-day tour of works in South Wales. This had been a very successful enterprise, the party being most heartily welcomed by all the firms visited, and all those who took part agreed that it had been highly worthwhile from a technical point of view.

The major technical event of the year had been the special Conference on " Cold Extrusion of Steel " held in the City Hall, Sheffield, on November 21 to 23. Over 320 people had registered for the Conference, at which 11 papers were presented and discussed, and it had been the general concensus of opinion that the Conference had inaugurated a new era of interest in the process in this Country. This had been borne out by the response received by the Cold Extrusion Sub-Committee to its questionnaire sent out following the Conference, as a result of which a further meeting was to be held in the near future to discuss a programme of co-operative research, in which over 50 firms and research establishments had expressed interest.

Other Sub-Committees of the Technical Committee were also engaged in investigational work, to two of which the Chairman made mention. The Testing and Measurement Sub-Committee was investigating the definition and measurement of grain-size and grain-shape and their significance in relation to the utilization of sheet metal; and the Surface Treatment and Finishing Sub-Committee was carrying out an assessment of currently

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Institute of Sheet Metal Engineering

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available electrolytic and chemical processes for polishing stainless steel and aluminium.

In concluding his report, the Chairman expressed his thanks to all members of the Council and its numerous committees and sub-committees, for their loyal and enthusiastic support during the past year. He also paid tribute to the work of the Secretariat, and in particular that of the Assistant Secretary, Miss R. Clark, for her indefatigable activity in shouldering the bulk of the administrative load.

Following the adoption of the Report the Chairman said that it gave him great pleasure to invite the meeting to confirm the election of Mr. E. W. Hancock, O.B.E. as President of the Institute for the next two years. The Institute had been most fortunate in recent years in having a series of Presidents who had lent their enthusiasm and support to the pursuit of its aims and he wished to convey a particular warm expression of thanks to Mr. John Ryan, who was relinquishing the office after a four-year term during which he had consistently interested himself in the Institute's affairs and exerted his influence on its behalf. In welcoming Mr. Hancock to his presidency, Mr. Gilbert said that there was no need for him to elaborate on Mr. Hancock's long and distinguished record in the motor industry, which in itself bore ample testimony to his energy and wisdom, and the Council had been most gratified by his ready acceptance of their invitation.

The Hon. Secretary then reported that the following members had been elected to fill the seven vacancies on Council :—

*Dr. W. E. Hoare:	Tin Research Institute.
*Mr. H. A. Holden:	The Pyrene Co. Ltd.
*Mr. F. B. Hooper:	Industrial Newspapers Ltd.
*Mr. G. H. Lawrence:	John Thompson Motor Pressings Ltd.
*Mr. R. E. Leakey:	Power-Samas Accounting Machines Ltd.
*Mr. E. N. Salmon:	The Austin Motor Co. Ltd.
Mr. F. G. Pullin:	Hordern, Mason and Edwards Ltd.

* (Retiring member of Council, re-elected for further term.)

This concluded the formal business of the meeting which was followed by a luncheon, at which the new President delivered his Presidential Address.

Improved Spring Alloy

JOHNSON MATTHEY & Co., LTD. announce the development of Mallory 53, a nickel-silicon-copper alloy spring material with mechanical properties at least equal to those of the conventional phosphor-bronzes and brasses, but with appreciably higher electrical conductivity. Because of the exceptionally high electrical conductivity of the alloy, 40 to 45 per cent I.A.C.S., it is possible for springs of small section to carry appreciable currents and advantage can be taken of this characteristic to increase the current rating of existing designs of springs. All spring forming operations can be applied to Mallory 53 after heat treatment and hence the alloy is supplied in the precipitation-hardened condition requiring no further heat treatment by the user. Further details can be obtained from the company at 73-83 Hatton Garden, London, E.C.1.

FOR OUR OVERSEAS READERS

(Continued from page 397)

Résumés des Principaux Articles

traite de sujets tels que le contrôle de la largeur, du calibrage, de la longueur et de la section transversale, et il donne des renseignements sur l'équipement nécessaire pour réaliser la commande désirée. Ce chapitre comprend également une section sur la finition de la surface dans les trains à bandes à chaud et les laminoirs à froid.

Zusammenfassungen der Hauptartikel

unter werden u.a. die Regelung von Breite, Dicke, Länge und Querschnitt behandelt und die dazu erforderlichen Einrichtungen beschrieben. Ein Abschnitt ist der Oberflächenbeschaffenheit im Warm-Bandwalzwerk und im Kalt-Reduzierwalzwerk gewidmet.

Résumenes de los Artículos Principales

como el ancho, el espesor, el largo y el corte y se ofrece información sobre el equipo necesario para efectuar el control deseado. También está incluída una sección que trata del acabado de superficies en el laminador de flejes en caliente y en el laminador de reducción en frío.

SHEET METAL NEWS

FEATURING EVENTS AND PERSONALITIES IN THE INDUSTRY

GERMAN ROLLING-MILL MANUFACTURERS ENTERTAIN BRITISH COLD-ROLLING INDUSTRY

FROM May 1 to 6 last the West German manufacturers of rolling mills, Rheinische Walzmaschinenfabrik, G.m.b.H., entertained a party of representatives of the British cold-rolling industry at a convention in Cologne. The convention included a visit to the R.W.F. works at Cologne to see mills and ancillary equipment under construction and to nine works rolling both ferrous and non-ferrous strip from narrow to wide widths on mills of the company's manufacture. An interesting feature of these visits was that the opportunity was given to see both older and new mills so that an assessment of progress in the design of the mills over the last ten years or so was able to be made. The convention was one of a series being organized by the company, and, in addition to the British representatives who constituted the main part of the party, members of the cold-rolling industries of Sweden, Denmark, France and Switzerland were also present.

British firms represented were J. B. and S. Lees Ltd., West Bromwich; Graham Firth Steel Products Ltd., Walsall; Ductile Steels Ltd., Willenhall; British Rolling Mills Ltd., Tipton; B. M. Rolling Mills Ltd., Birmingham; Lancashire and Corby Steel Mfg. Co. Ltd., Corby; Effingham Steel Works Ltd., Sheffield; Samuel Fox and Co. Ltd., Sheffield; Arthur Lee and Sons Ltd., Sheffield; Fnfield Rolling Mills Ltd., Brimsdown; Guest Keen and Nettlefolds Ltd., Cardiff; Stourbridge Rolling Mills Ltd., Stourbridge; and Lancashire Dynamo Electronic Products Ltd., Rugeley, Staffs.

Rheinische Walzmaschinenfabrik was founded in 1907 by Mr. R. Mueller and current production from the works includes hot- and cold-rolling mills, de-coilers, coilers, straighteners, roller levellers, rolls and roll grinders, and mixing machines for the paint and chemical industries.

At the R.W.F. works it was pointed out that, in general, it is the company's policy always to use extremely strong housings and most of the modern cold mills built by the company have an interesting method of roll changing. With this system on a four-high mill, for example, the bottom back-up roll and the work-rolls are pushed from the rolling position as a unit through the side frames of the mill by hydraulic cylinders. The two work-rolls and bearings are then removed by overhead crane and replacement rolls put in position and the whole unit with the back-up roll retracted into the mill. A demonstration roll change in a customer's works took well under five minutes.

Two 3-stand tandem mills with 8-in. and 6-in. dia. rolls respectively were seen at the works of Felton and Guilleaume, Köln-Mülheim. Rolling narrow copper strip about 2½ in. and 1¼ in. wide, these mills had finishing

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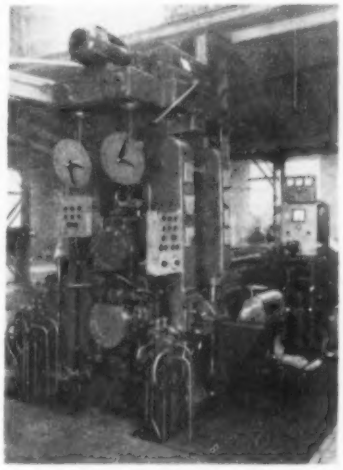
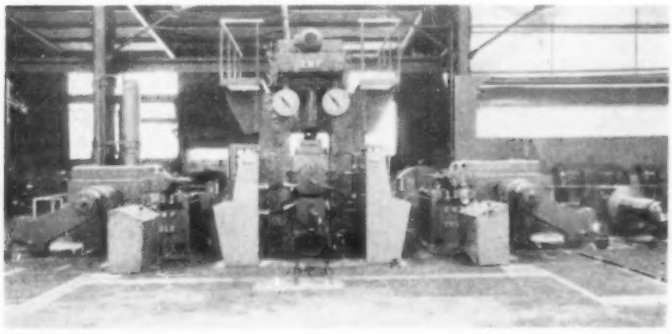
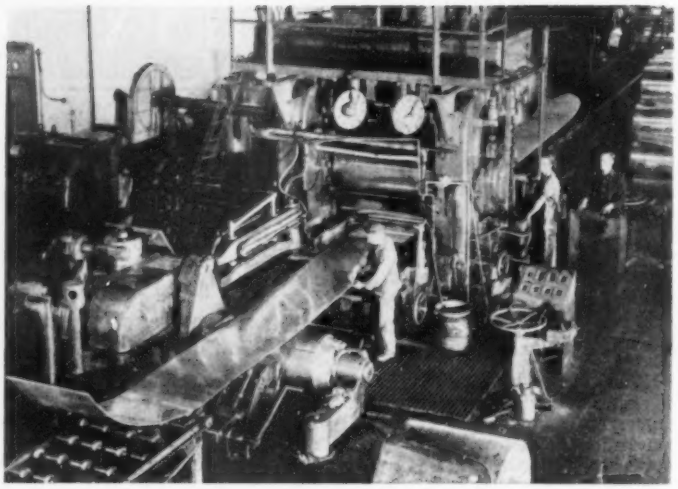




Above is shown the 4-high one-way mill at the works of Kaltwalzwerke Velbert Aktiengesellschaft, Nierenhof which is used for rolling various grades of carbon-steel strip. In constrast the mill on the left, at Vereinigte Aluminiumwerke, Bonn, is a 4-high reversing mill used for finish passes on aluminium. This mill has built-in shears and automatic gauge control

German Rolling Mills

(*Continued from page 461*)



The 4-high reversing mill at V.D.M., A.G., Eveking. This mill is fitted with a.c. drive and is used for rolling copper strip

speeds of 1,500 ft. per min. On both the mills the speed on stand 3 was controlled by the tension on the strip in stands 1 and 2. A tensiometer arrangement was also used to control the speed of the coiler. Power supply for one mill was from an m.-g. set and the other from rectifiers. On both mills the rolling sequence involved breaking down (stand 1), breaking down and width control (stand 2) and rolling for final thickness on stand 3, the screwdown on this stand being automatic. On the smaller mills the control equipment of Jovy manufacture was transistorized; control of the larger mill was by Rega equipment.

A 4-in. two-high tandem mill at Bremshay and Co. (Solingen) was shown rolling high-carbon steel strip (from 3.5 mm. dia. wire) about ½-in. wide, the drive being through an electromechanical system of Inducta Getriebebau, Dusseldorf. Tensiometer control of speed was fitted to stand 1 and an interesting feature of this mill was that the rolls were fitted with carbide sleeves.

At Kaltwalzwerke Velbert Atkiengesellschaft, Nierenhof, a 4-high one-way mill with 5-in. work rolls and 13-in. back-up rolls was shown rolling low, medium and high-carbon steel strip down to 0.012 in. thick and from 1 to 8½ in. wide. This company are, in effect, stockholders and supply material to customers' requirements. The mill, which was a.c. driven, incorporates a hydraulically adjusted billy roll which is claimed to have advantages when rolling very thin strip. Emicron gauging equipment is incorporated in this mill. Coiler tension is over the range 300 to 3,000 lb. All material is shotblasted and not pickled in the usual manner.

At V.D.M., A.G., Eveking, the mill was a 4-high reversing mill with 14-in. work-roll diameter, 32-in. back-up roll diameter, and a rolling speed of 200 ft. per min. This mill, which was seen rolling copper strip, is equipped with a run-out table which is used for early passes, and a rotary shear between the coiler and the mill. A "vacuum cleaner" is fitted to the mill for removing rolling lubricant from the edge of the strip during the last pass. The rolling schedule was for seven passes in which the strip was reduced from about 0.36 to 0.04 in. This mill has full a.c. drive.

The mill, a 4-high reversing type, seen at Union Works, Fröndenberg, was that on which the R.W.F. rapid roll change was demonstrated. This mill, which was installed in October, 1960, has 7-in. work rolls, 18-in. back-up rolls, a barrel length of 18-in. and a rolling speed of 500 ft. per min. The d.c. drive has Ward-Leonard control, and the mill, which also has built-in feed rolls, has full A.G.C. using Solex gauging equipment and electrics and electronics by the firm of Hans Still, Hamburg. The normal material rolled on this mill is mild steel with a maximum width of about 14 in. but 0.5 to 0.6 per cent carbon steel is also rolled. The rolling lubricant cooling and filtration equipment has a capacity of 65 gal. per min. and was also built by R.W.F.

The ½-in. ingoing thickness is reduced to 0.02 and sometimes to 0.01 in. The total roll pressure available is about 300 tons, but normal practice requires about 220 tons. The lubricant system consists of two tanks of 800 gal. capacity, the filtered oil being stored in the second tank in which it can be heated or cooled as required. The coilers have a 20-in. drum dia. and have no outboard support bearing, the ratio of coiler tension available being 1 : 10 with a maximum of 7,000 lb. The main motor is rated at 370 kW. and the screwdown speeds are 0.07 mm. per sec. and 0.7 mm. per sec. This mill has built-in shears and roller bridle equipment—used only on the first pass.

A 4-high reversing mill, built in November, 1960, and incorporating a recoiling unit and a built-in shear, was seen at the works of Risse and Wilke, Höhenlimburg. This mill has a work-roll dia. of 6 in., a back-up roll dia. of 15-in. and a roll barrel length of 16 in. The 500-h.p. d.c. drive gives a maximum rolling speed of 800 ft. per min. The coilers have a tension adjustable between 700 and 7,000 lb., and full A.G.C. is incorporated. The lubricant filtration plant is similar to that on the Union mill previously mentioned.

Designed to roll steel up to 0.6 per cent carbon, this mill uses an ingoing thickness of about ½-in. and can roll down to 0.004 in. although the planned outgoing thickness is 0.01 in. The total reduction obtained without annealing is 90 to 92 per cent.

A pay-off reel is part of the design and the ancillary equipment also includes a rotary slitter positioned between the mill and the coiler. The cutting heads on the slitter are interchangeable. Roll changing is by the special R.W.F. system and Emicron gauging equipment is incorporated.

It is interesting to note that about 75 per cent of the cold-rolled mild steel produced in Western Germany comes from the Höhenlimburg area.

One of the earlier "modern" mills built by R.W.F. was seen at the works of Friedrich Gustav Theis. This 4-high reversing mill was built in 1957, and has 8-in. dia. work-rolls, 22-in. dia. back-up rolls and 32 in. barrel length. The maximum rolling speed is 800 ft. per min., the coiler tension ratio being 1 : 15. Direct measurement

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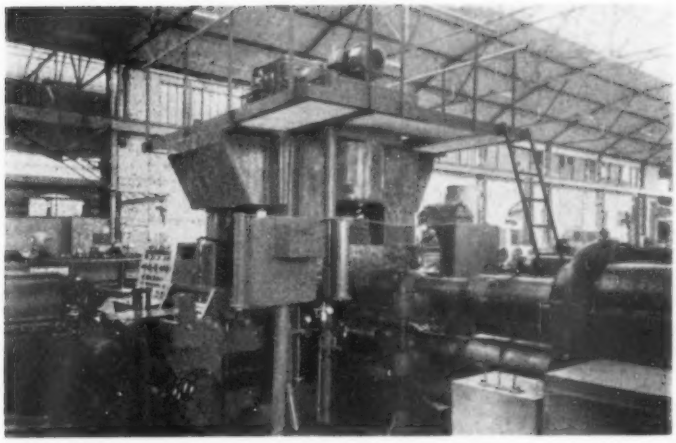

The mill at Dürener Metallwerke, Duren. This is a 2-high reversing mill used for rolling brass. It is d.c. driven, has a 7-roll bridle on each side of the mill, and incorporates full A.G.C.

German Rolling Mills

(*Continued from page* 462)

of tension is provided on this mill making the distance between the coiler and the mill rather large as compared with up-to-date practice. The coiler drums are typical of R.W.F. design with hydraulically actuated wedges within the drum. The emulsion oil plant is similar to those described previously the capacity being 100 gal. per min., with the storage tank of 2,500 gal. capacity. The mill is fitted with full A.G.C. and rolls a coil of maximum width of 24 in., the weight of the coil being 8 kg. per mm. width which is a standard in Germany.

The general rolling programme on this mill involves prerolling on a 2-high mill with 4 to 7 passes on the 4-high, followed by annealing and skin passing. On the 4-high the ingoing gauge is about $\frac{1}{10}$ in., the finished gauge being 0.01 in. On both sides of the mill there is a built-in guillotine-type shear, and the gauge control equipment etc. is by Rega.

Dürener Metallwerke, Duren, produce light metals, brass and copper, and demonstrated a 2-high reversing finishing mill rolling brass. This mill has an 18-in. roll dia. and a 32-in. barrel length, the rolling speed being 330 ft. per min. The drive is d.c. and a 7-roll bridle is provided on each side of the mill. Full A.G.C. is provided (Hans Still, Hamburg) with Solex gauges, and tension reels are fitted each side of the mill plus a coiler on the exit side for the final pass. Also incorporated on the mill are built-in shears of the guillotine type. The mill tables incorporating the bridles are hydraulically raised out of the mill at an angle of about 45 deg. for roll changing by the usual R.W.F. system. The mill also incorporates load cells; the drive is d.c. also incorporating Ward-Leonard control.

The rolling of aluminium was seen at Vereinigte Aluminiumwerke, Bonn; the mill being used was a 4-high reversing finishing mill with a work roll dia. of 10 in., a back-up roll dia. of 22 in. and a barrel length of 32 in. This mill was installed in January, 1961 and has a d.c. drive. The rolling speed is kept low in order to avoid the production of excessive temperature during rolling. This mill has a built-in guillotine shear on each side of the mill and A.G.C.

* * *

Although the details of the mills seen are necessarily brief the above information indicates the way in which R.W.F. had not only shown mills built over a period of time so that progress in design could be appreciated, but also mills handling a very wide range of strip dimensions and materials both ferrous and non-ferrous.

The thanks of the party taking part in this visit are most sincerely expressed to Dr. K. Hölling who was such an admirable host in Germany, and to Mr. H. G. L. Sambrook and Mr. B. Dowding of F. W. Kubach Ltd., London, the British Agents of R.W.F., for their assistance and co-operation before and during what was a most instructive week viewing German cold-rolling installations and practice.

It is interesting to note that as a result of this convention F. W. Kubach Ltd. have been appointed main contractors for an R.W.F. mill shortly to be installed in the U.K. This mill will have Lancashire Dynamo drives and control equipment, and Taylor, Taylor, Hobson micrometers.

OBITUARY

Mr. Ernest E. Thum, editor-in-chief of *Metal Progress*, died on April 10. Well known on both sides of the Atlantic, Mr. Thum started *Metal Progress* on behalf of the American Society of Metals.

* * *

Pressed Steel Co. Ltd. regret to announce the sudden death of **Mr. Eric George Rowledge,** a local director of the company and the senior director of the Prestcold division, which took place during a visit to the Swansea plant.

Mr. Rowledge, who was 62, had served the company for 27 years. A leading figure in the British refrigeration industry he had travelled widely and was a recognized expert in his field.

He was chairman of the British Refrigeration Association, and chairman of the Domestic Refrigerator Development Committee.

He leaves a widow, son and daughter.

B. ELLIOTT ACQUIRE BROADWAY EQUIPMENT

B. ELLIOTT and Co. Ltd., announce that they have acquired the share capital of Broadway Equipment Ltd., who are the sole licensees for Great Britain and a number of Commonwealth countries of the well-known French range of brake presses manufactured by Promecam of Paris. Broadway also hold a number of other important sole agencies for foreign machine tools.

"FAIR ORIANA"—A NEW FILM FROM UNITED STEEL

A FURTHER film in the excellent series available from the United Steel Companies Ltd. was given its premiere in London recently. The film tells the story (in colour) of the T.S.S. *Oriana* built for the P. and O. Orient line by Vickers-Armstrong (Shipbuilders) Ltd. at their Barrow yards.

In the opening sequence the vessel is seen from the air, steaming on her sea trials. The scene then switches to the plate and section mills of Appleby-Frodingham Steel Co., Scunthorpe, which contributed large tonnages of steel to the vessel's construction.

As well as having stabilizers, the *Oriana* is fitted with manoeuvring jets which enable the captain to give the unique order: "Full speed—sideways!" Every modern liner has many miles of water pipes and tubes and ventilation ducts, many of which are formed from steel strip, and the film shows hot-rolled strip being produced in the modern Brinsworth mill of Steel, Peech and Tozer, Rotherham.

There are some spectacular shots of the launching of *Oriana* by H.R.H. Princess Alexandra on November 3, 1959, and a closer look is then taken at some of the interior features of the vessel: the great forged steel propeller shafts in the engine room, the extensive use of stainless steel in the galleys, coupled with appropriate production sequences at the steelworks. The industrial designer, Robert Welch, is shown at work on the prototypes of the stainless-steel cutlery which he designed specially for use on the liner.

For the maiden voyage, the film switches dramatically from colour to black and white so that this memorable occasion can be seen on the ship's own closed-circuit television. In the gathering dusk of a dull December afternoon, *Oriana* drops the pilot and sails off on the long voyage to Australia.

Produced by Wallace Productions Ltd., the film runs for 28 minutes and is photographed in Eastmancolor.

Other films in the United Steel series are: "Steel Ride" (black and white); "Steel Rhythm" (colour); "Steel Road" (colour); "Steel Town" (colour); "Continuous Casting" (colour). Except for "Continuous Casting" which is obtainable only in 16-mm. all the films are available in 16-mm. and 35-mm. stock. These films may be borrowed on application to The Public Relations Officer, The United Steel Companies Ltd., The Mount, Broomhill, Sheffield, 10.

P. & O. 42,000 ton passenger liner "ORIANA"

SPAIN: A CHALLENGE AND AN OPPORTUNITY

THE Report of the FBI Delegation to Spain has now been published and is entitled "Spain: A Challenge and an Opportunity".

The visit was in response to an invitation from the Consejo Economico Sindical Nacional, which sent a party of high level industrialists to the United Kingdom in April, 1960. The objects of the visit were to study the Spanish economy in the light of the recent Stabilization Plan; to examine the possibilities for increasing Anglo-Spanish trade and how the U.K. could help in Spain's development programme; and to obtain full details of the Spanish Foreign Investment Legislation.

Sir William McFadzean, who led the delegation, says in the Foreword of the report that there is little immediate prospect of selling certain consumer goods, but there are good prospects for supplying plant, equipment and machine tools, and for entering into mutually beneficial partnerships. He said that more British industrialists should visit Spain, not only to see for themselves the potentialities of the market, but also because the Spaniards place a particular importance and value on personal contacts.

Copies of this report are obtainable from FBI Print and Publications, 21 Tothill Street, London, S.W.1, price 7s. 6d. post free (excluding airmail).

CHANGES OF ADDRESS

F. W. KUBACH, LTD., established in 1910 in the City, and who celebrated their 50th anniversary last year, have moved to larger and more suitable premises at Wakefield House, 106 Church Road, London, S.E.19. Telephone, Telex and Telegraphic address remain unchanged.

THE new address of Reynolds and Wilson Ltd. is now Lion House, Red Lion Street, Richmond, Surrey. Telephone: Richmond 7667/9.

This is also the new London address of the company's various Principals, as follows: Denham's Engineering Co. Ltd., Fredk. Town and Sons Ltd., Abwood Machine Tools Ltd., Scottish Machine Tool Corporation Ltd., John Pickles and Son (Engineers) Ltd.

BERNARD CONWAY (Metals) LTD. have now moved to 19 Queen Street, Mayfair, London, W.1. Telephone and Telex numbers remain unchanged.

THE new address of Bartella Ltd. is 19 Queen Street, Mayfair, London, W.1.

Telephone number will remain as previously, i.e., GROsvenor 3369, and Telex number 23369 also remains unaltered.

Books for Your Library

A History of Metals (2 volumes) by Leslie Aitchison, D.Met., M.Sc., F.R.I.C., F.R.Ae.S., M.I.Mech.E., F.I.M. Published by Macdonald and Evans, London, 1960. 690 pp., 260 illus., 48 tables. Price £8 8s. (2 vols.)

THIS book (two volumes) is a tremendous work undertaken with great care by a metallurgist of established reputation who has done his best to be objective. The book is very well produced and contains many excellent illustrations—some really beautiful. There are remarkably few misprints (the boiling point of zinc is given as 927°). The headings of some of the chapters are refreshingly unusual while the notes and references at the end of each chapter are adequate for anyone wishing to read more deeply into any particular aspect—there is a pleasing absence of the innumerable references one usually finds in a book of this kind, which interrupts the continuity of one's reading and enjoyment and which are rarely used. An adequate list of sources of information is given at the end of the book. There is sometimes an unexpected looseness of expression.

One can agree with the opening "It is generally held today that the contemporary way of living in all the more advanced societies is almost entirely based on the use of metals; it would certainly be difficult to conceive a modern life without them". It must be recognized that man's ascent through the ages is due to his increasing knowledge of the use of metals and although the bronze age followed the neolithic and in turn was followed by the iron age, fortunate was the tribe or family in neolithic times into whose midst fell a piece of meteoric iron which could be fashioned into tools or weapons. It is still interesting to speculate how figures and hieroglyphics could be cut to a depth in some cases of no less than 2 inches in granite or porphyry. Chisels and wedges of bronze would be of little use for shaping and cutting these hard stones. The stone, bronze and iron ages are not definite periods in the history of man but stages in the development of particular tribes — depending among other things on the location of various easily smelted ores. One part of the world in prehistoric times may be in quite a different "age" from another. Iron production in small furnaces in the middle of Africa is carried on today as it was many hundreds of years ago in Africa or in India, China and Europe. Even alchemy emerged in various parts of the world at different times—in India 1000 B.C., in China 300 B.C., in Europe 100 A.D. Whether the first chapters dealing with ancient times should be written by a historian, by an archaeologist or by a metallurgist is difficult to decide but in this book the tale is told in a most interesting way and from the metallurgist's view, accurately. There is so much that is absorbing that it is difficult to select any topic. Possibly the part played by the Romans. By the end of the third century B.C. they had become the most important metallurgists in the world and made many developments in the use of metals. All metal found in the territories dominated by them belonged to Rome and the skills included not only the winning, casting and fabricating of metals but their use in the aesthetic field. With the decline and disintegration of the Roman Empire, 450-500 A.D., metallurgy suffered not only an arrest in development but stagnation and even a loss of some of the old metal crafts. Interest was revived about 700 A.D. and the Celts and the Anglo-Saxons maintained and improved some of the metal crafts. Then came the rise of ecclesiastical establishments which became active and important promoters of metallurgical enterprises and used metals more widely in the general life of the community.

In the last chapter of the first volume the author pauses from the descriptive narrative and considers "thinking about metals". He writes about the attention paid by philosophers of the times to the knowledge accumulated over several hundred years by wise men in China, India, Japan, Asia and Egypt. There was much speculation on the nature of matter and its essential properties from Sumerian times to about 1500 A.D. It is the dawn (almost imperceptible) of a new approach to metals—not the scientific approach so much, as we understand it today. It is the end of the so-called dark ages, and is the age of alchemy.

The author writes an interesting story of the alchemists—a curious mixture of philosopher, physician, theologian, metallurgist, chemist and astrologer. They were, however, the chief laboratory workers of the time and they left a rich harvest of facts. They did not, however, combine theory with fact finding. They ignored experimental results which did not agree with their philosophy of the transmutation of metals with the aid of some "all powerful thing" (stone, elixir, etc.). However, at the end of the 17th century the establishment of facts as a result of experimental work became increasingly important and this era saw the work of Paracelsus—the chemist, and Agricola (George Bauer) the metallurgist—both of whom were alchemists on the verge of becoming what we may recognize nowadays as scientists. The honest alchemist by his careful recording of laboratory experiments and development of apparatus contributed much to the history of metals—without this the later history of metallurgy might have been quite different.

The middle ages saw the development of mechanical aids which enabled larger equipment to be used in the winning, smelting and fabricating of metals. It also saw the growing importance of European metallurgy and, especially during Tudor times, the rapid advances in this country. The author gives an interesting story of the spectacular developments during the last 100 years—(mild steel was not known in 1850 and the heavy industries used cast and/or wrought iron). This advance owes so much to chemistry, and to engineering both electrical in the extraction field and for the controlled movement of large masses, and to the mechanical engineer who is the chief user of metal products. Much of this story inevitably becomes chronological and the interesting point is made that about 1890 might be considered the transition from old metallism to new metallurgy—what metallism really means is not clear. An interesting letter from Sorby to Hadfield in 1906, is reproduced for the first time. It is a fitting comment on the achievements of the first half century of modern scientific metallurgy. "The possibilities of making new alloys can now with some confidence be assessed in advance, and the limitations applying to the compositions of phases in alloy systems may be forecast".

In the last chapter the author pauses once again to survey the position. He ends on a provocative note when he mentions the creation by man of metals that appear never to occur in nature and that these "man-made" elements are of some interest and that one at least of them has been produced already in quite appreciable large quantities. "It is believed from basic physico-chemical considerations that no element having an atomic number higher than 108 can be expected and if this view be correct only six more metals

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are ever likely to be created". History is the one field of study in which it is not possible to start at the beginning—is there any reason to suppose it has an ending? No one can state that there is no more!

The author ends on a high note—"How better can modern metals serve man than by supplying usable energy for peaceful purposes, in quantities that may eventually be virtually limitless and by providing a variety of radio-active isotopes that will check disease and relieve the sick. Achievements such as these could never be the stigmata of an anticlimax".

PROF. W. R. D. JONES

Determination of the Mechanical and Technological Properties of Metals, by B. M. Gliner. Translated from the Russian 2nd edition, 1960. Pergamon Press, Oxford: London. 160 pp. Price £2 10s.

THERE is no padding in this book. Methods are described to a plan that gives definitions of the characteristics measured, the basic expressions used, dimensions of test pieces, test procedures, and finally diagrams of equipment.

Tests of the usual mechanical properties are dealt with in Part I. The inclusion of acoustic and radiotechnical methods for determining Young's modulus and the modulus of rigidity is unusual but useful. There are details of tensile testing with miniature test pieces, micro-hardness determination, and on testing at elevated temperatures.

In Part II is given a comprehensive series of tests for welded joints and weld metal.

Finally, in Part III are described many miscellaneous tests. Some are of the kind given in B.S. Handbook 13, but others, like the tests for machineability, hardenability and weldability are not in Britain included in normal mechanical tests.

Information is in accordance with current Soviet specifications, relevant numbers often being given. Descriptions of machines, though brief, are interesting. For instance, the hardness testing machine PB-3 for workshop use, although it looks crude, must be cheap to make; and the method of applying the load of portable tester ShP-O.75 is unusual.

There are differences between Soviet and British practice: B.S.-1452 for the transverse test for cast iron allows machining of the test bar, Soviet practice does not. The Soviet test, incidentally, is called the bend test; the transverse rupture test is something quite different.

To have all this information together is valuable to metallurgists, engineers, and translators. The last will find definitions of terms and symbols most useful, although "extensometer" is better than "tensometer" (p.4).

The only real criticism is that some diagrams are too small for clarity. Other criticism of presentation is disarmed by the notice that letterpress setting would have meant delay and increased price. As it is there is good value for money, and prompt publication is, in instances like this, preferable to attractive format.

The Translation Editor's claim that "the book's main use will be as an authoritative source for the quantitative interpretation of the mechanical test data to be found in the Soviet literature" is reasonable.

N. S. ANGUS

The Brittle Fracture of Steel, by W. D. Biggs. MacDonald and Evans, London, 1960. 450 pp. Price 70s.

ANYONE undertaking the task of preparing a critical review of the literature on the brittle fracture of steel at the present time deserves admiration. It must be a very intrepid author indeed who is not frightened by the contemplation of this herculean task. There have been two American books on the same subject in recent years which, good as they were, nevertheless suffered from the serious defect of ignoring much of the literature on the subject which had appeared outside the United States.

Dr. Biggs' book starts properly with a summary of recorded information on failures in service and goes on from there to consider the fundamental mechanical aspects of deformation and failure. The effect of temperature, strain rate and metallurgical factors including radiation damage is considered in the next chapter. Initiation and propagation of fracture are considered in two separate chapters and mechanical tests in use for the estimation of brittle fracture propensity are reviewed critically and fairly comprehensively. Notable omissions in this otherwise very comprehensive chapter are the German Kommerell test which for many years was used with some measure of success by the German state railways particularly for the testing of flange plates for girder bridges and the Messayer test which is still used in Russia as the approved acceptance test for material. A discussion of the shortcomings of these tests would have been instructive. The effect of metallurgical variables is very thoroughly considered in Chapter 10 and the book concludes with a section on the effect of welding, a final chapter on residual stresses and a valuable summary.

The book deserves unstinted praise and admiration and if any criticism of it is made it must be said at once that no-one could have written a better book, though naturally different authors would be expected to have perhaps placed the emphasis in a different way. One failing of the book, if it may be called that, is the indifference of the author to the important distinction of brittle fracture as such and low stress brittle fracture. It is only the fracture which takes place at low applied stresses at or below permissible values which causes concern. While to the scientist both may be merely different facets of the same fundamental problem, to the engineer the distinction is important because it has very far reaching practical consequences. Provided low stress brittle fracture can be avoided the engineer can forget about the problem. Measures sufficient to avoid low stress fracture would not necessarily be adequate to avoid brittle fracture at yield point stress.

All books of necessity suffer from the fact that some considerable time must elapse between going to press and appearing in the bookshops. With a subject so actively pursued as brittle fracture this is particularly regrettable. The author could obviously not quote any of the deliberations of the conference held in Cambridge in September 1959, which it is hoped will appear in print soon. With the proceedings of this conference and Dr. Biggs' book we shall at least have a summary of the position as for September 1959.

R. WECK

NEW STOCKHOLDERS

WELBECK TRADING CO. (LONDON) LTD. announce that they are now associates with a newly-formed company, namely Welbeck (Steel Stockholders) Ltd., who occupy a 68,000 sq. ft. site at Steel Wharf, River Road, Barking, Essex. A new warehouse is being erected and will contain handling, shearing, cropping, and profile cutting equipment. Comprehensive stocks of sheets, plates, strip, sections, angles, flats, tinplate and blackplate, etc., will be maintained.

APPOINTMENTS and STAFF CHANGES

The Steel Company of Wales Ltd. announce that Mr. Godfrey Walker has been appointed public relations officer and that in future he will be based at the London office Margam House, St. James's Square. London, S.W.1. In his new position he will have the additional duties of advising the chairman and the sales controller on matters affecting prestige and commercial advertising. Mr. Walker joined the company in 1947 as information officer at Port Talbot and has been responsible for the press relations and publicity in the steel, tinplate and Newport divisions throughout the company's post-war development schemes.

Mr. Wendell Leyshon, assistant information officer, has been appointed information officer and will take over the duties formerly carried out at Port Talbot by Mr. Walker.

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The Governors of **Borough Polytechnic** announce that the following members of the academic staff will be promoted as from September 1, 1961: Chemistry and Food Technology, Mr. D. R. J. Holdsworth, lecturer in chemical engineering, to the rank of senior lecturer; Dr. J. A. Speed, assistant lecturer (Grade B) in inorganic chemistry, to the rank of lecturer; Mechanical Engineering—Mr. J. F. Heward, lecturer in mechanical engineering, to the rank of senior lecturer.

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Mr. G. D. Jordan, who presided over the fourteenth annual conference of the **Institution of Plant Engineers** is the youngest president in the history of the Institution. Born in 1925, he graduated from Sheffield University with the degree of B.Eng. in 1944. After service with the Royal Navy, he joined United Steel Companies', Samuel Fox and Co. Ltd., branch in 1947 as technical assistant to the chief engineer. He was appointed lubrication engineer in 1948 and transferred in 1956 as senior engineer in United Steel's department of operational research and cybernetics. Mr. Jordan is at present project secretary for the operation "Spear" electric melting shop scheme at Steel, Peech and Tozer.

Sir Arthur Vere Harvey, C.B.E., M.P., has been appointed to the board of **CIBA Ltd.,** Basle. This is the first time that an executive of the CIBA group of companies in Great Britain has been made a director of the parent company and may be considered as an indication of the importance attached by the Swiss board to the role of the British companies in this international chemical group.

Recently Sir Arthur was appointed managing director of the newly-formed CIBA United Kingdom Ltd., which is acting as the holding company for all CIBA interests in Great Britain.

Other directors of CIBA United Kingdom Ltd. are: Dr. Dr. h.c. R. Käppeli (chairman), Dr. Dr. h.c. A. Wilhelm, Dr. A. Brunner, Sir Joseph Napier, Bt., O.B.E.

* * *

The **London Shafting and Pulley Co. Ltd.** of Collingwood Iron Works, 18-22 Northdown Street, London, N.1, announce the following changes of personnel: Mr. G. C. Hart has become sales manager (Home) in succession to Mr. F. N. Honey who is now general manager. Mr. E. J. Metcalfe will shortly take up the appointment of Western area representative based in Exeter.

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Mr. B. J. Harpham, of **Collingwood Conveyor Equipment Ltd.,** Collingwood Iron Works, 18-22 Northdown Street, London, N.1 has been appointed managing director.

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The **Plessey Co. Ltd.** announce the appointment of Dr. A. W. Henderson, Ph.D., B.Sc., as chief chemist/metallurgist. Dr. Henderson, a graduate of Edinburgh University, will work at the company's Ilford headquarters.

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Mr. Kenneth Arthur Oliver has been appointed chief metallurgist of the **Brightside Foundry and Engineering Co. Ltd.,** Sheffield.

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Mr. E. A. Elmore has recently been appointed to the board of **Gate Machinery Co. Ltd.**

Mr. Michael J. S. Clapham, who has been chairman of **I.C.I. Metals Division** since January, 1960, has been appointed a director of I.C.I. He is to be an overseas director vice Dr. J. S. Gourlay who is to be Group A Director (responsible for Alkali and General Chemicals Divisions).

Mr. Clapham is a director of Pyrotenax Ltd., Yorkshire Imperial Metals Ltd. and Imperial Aluminium Co. Ltd., chairman of the Non-Ferrous Wrought Metals Export Group, and a vice-president of the British Non-Ferrous Metals Federation.

Mr. Harold Smith, who has been chairman of I.C.I. General Chemicals Division for the past two years, has been appointed a director of I.C.I. He takes over as Technical Director from Dr. Richard Beeching.

* * *

A single Publicity Department of **Associated Electrical Industries Ltd.** known as the AEI Publicity Department came into operation in April, based at Crown House, Aldwych, London, W.C.2. The department serves all the product divisions of the company and its principal wholly-owned subsidiaries in the U.K., with the exception of AEI-Hotpoint Ltd., AEI-Gala Ltd. and AEI Lamp and Lighting Co. Ltd.

The following appointments have been made: general manager, Sir Arthur Elton; assistant general manager and head of public relations section, Mr. R. H. Veysey; manager, media and technical information sections and head of administration, Mr. H. H. Lusty; joint managers, product publicity section: heavy products, Mr. O. W. J. Farmer, light products, Mr. T. M. McLellan; manager, publications group and Manchester office, Mr. J. Dummelow; manager, Rugby office, Mr. H. G. Harlow.

A single press office has been established at Crown House, Aldwych, London, W.C.2. The chief press officer is Mr. S. R. White assisted by Mr. J. F. Amor, Mr. A. Davis and Miss K. Rowe. Mr. P. C. Spencer is information officer at Rugby and Mr. D. Gill information officer at Manchester. Their functions are largely internal and press enquiries should be addressed to the London Press Office. Telephone No.: Temple Bar 8040 (after office hours: Belgravia 1234).

Mr. B. J. Collings acts as press officer for AEI-Birlec Ltd. (Telephone No.: Birmingham East 1544).

WAVERLEY GOLD MEDAL ESSAY COMPETITION 1961

"RESEARCH" is sponsoring The Waverley Gold Medal Essay Competition for the ninth year in succession. The competition is designed to encourage the scientist in the laboratory and the engineer in the production plant to express his views and translate his work into an essay that will be readily understood by other scientists, directors of industrial firms and others interested in science and technology.

The Medal, named after and bearing the coat of arms of the late Lord Waverley, together with £100 will be awarded for the best essay of about 3,000 words describing a new project or practical development in pure or applied science. The essays will be judged for technical content by specialists in the subject, for clarity of presentation and for style.

A second prize of £50 will be awarded and also a special prize of £50 for the best entry from a competitor under the age of thirty on July 31, 1961. Entry forms can be obtained from the Editor of "Research", 88 Kingsway, W.C.2.

CONTRACTS WORTH £5 MILLION SIGNED AT LEIPZIG FAIR

BRITISH firms concluded contracts worth £5,400,000 with East Germany at this year's Leipzig Spring Fair compared with £3,600,000 at the 1960 Spring Fair, and substantial orders were received for steel products and machinery.

East German orders with British steel firms totalled £487,000, including contracts worth £150,000 with British Ropes of Doncaster, £120,000 with Graham Firth Steel Products of Walsall, and £60,000 with T.I. (Export) of Birmingham. Yugoslavia placed two substantial orders with the English Steel Corporation of Sheffield.

East Germany also placed orders with Dowding and Doll of London for machines worth £11,000, and cranes and building machinery from Ransome and Rapier, Ipswich, K. and L. Steelfounders and Engineers, Letchworth, Steels Engineering Products, Sunderland, Aveling-Barford, Grantham, and Marshall Sons, Gainsborough, to the value of £55,000.

Further East German orders included: Fords (Finsbury) Ltd., Bedford, bottle topping machinery for £14,000; Sharples Process Engineers, London, centrifugal and process equipment for £66,000; Baker Perkins (Exports), London.

LARGE EXPORT ORDER FOR STEELWORKS PLANT

HEAD WRIGHTSON (AUSTRALIA) PTY. LTD., of Sydney (a subsidiary of Head Wrightson and Co. Ltd.) have received orders valued at approximately £3½ million from The Broken Hill Proprietary Co. Ltd. and from Australian Iron and Steel Ltd. The orders include the design, manufacture, and erection of a scree ore treatment plant, a basic oxygen steelmaking plant and a tinplate cut-up line.

The engineering for the ore treatment plant (capacity 1,200,000 tons per annum) will be carried out by Head Wrightson Minerals Engineering Ltd., Sheffield.

The order for the basic oxygen steelmaking plant is the first export order to be secured by a British firm for the supply of a complete plant using any of the new oxygen steelmaking processes. This plant, with an output of approximately 500,000 tons of steel per year, will be installed at Whyalla, South Australia, and will be engineered in the United Kingdom by Head Wrightson Iron and Steel Works Engineering Ltd., Thornaby-on-Tees. On this project Head Wrightson are responsible for the supply of two 100-ton basic oxygen furnaces together with the oxygen lancing equipment, fume ducting and fume conditioning equipment, the steel plant buildings, together with the hot metal and slag ladles, steel transfer cars, etc.

The tinplate cut-up line will be built to the designs of The Head Wrightson Machine Co. Ltd., Middlesbrough, and is a repeat order, a similar line having gone into production a few months ago at the Port Kembla Works of Australian Iron and Steel Ltd. Initially this line will be used to enable steel strip of up to 40 in. wide in coils weighing up to 45,000 lb. to be cut up into sheets suitable for hot-dip tinning. The line is designed to operate at speeds of up to 800 ft. per min. Near the entry end, and before the flying shear, flying micrometers and pinhole detectors will be installed which will enable sheets which are off gauge, or have a surface defect, to be automatically rejected in the classifying and piling device which follows the shear. The classifier on the line recently installed is the first four-pile flat-topped classifier with single sheet classification to be installed anywhere in the world. Ultimately, this cut-up line may be used to take coils of steel strip which have been electrolytically tinned and cut these into sheets of varying sizes to suit the requirements of the canning industry.

The engineering for the whole of this line and part of the equipment will be supplied by The Head Wrightson Machine Co., but the major part of the equipment will be manufactured in Australia.

Equipment and services valued at almost £1 million sterling, will be supplied from the Head Wrightson Works on Tees-side.

MANUFACTURE OF BIRLEC FURNACES IN AUSTRALIA

AN agreement has been made between AEI-Birlec Ltd., of Birmingham and Major Electric Furnaces Pty., Ltd., of Melbourne, Australia, for the setting up in Melbourne of a new company to be known as Birlec-Major Pty., Ltd., with offices in Chesterville Road, Moorabbin, Melbourne, who will manufacture every type of electric and gas-fired furnace for heat-treatment and melting processes at present built by Birlec and their associate companies in the U.K. In addition to serving the Australian market, the new company intend to market their products in New Zealand and S.E. Asia.

Since 1952 Birlec furnaces have been manufactured under licence by Major Electric Furnaces Pty., Ltd., and are installed in most Australian industries. This agreement now terminates with the formation of the new company.

AGENCIES

PRESS AND SHEAR MACHINERY CO. LTD., of 172-178 Victoria Road, Acton, London, W.3, have been appointed sole distributors and licencees for the complete range of upstroking hydraulic press brakes manufactured by Promecam S.A., of 63 Rue de Strasbourg, Saint Denis, Seine, France.

Press and Shear have a demonstration vehicle which is available to visit any firm interested in seeing this press brake in operation.

K. A. BALLARD LTD., of Woodthorpe, Church Road, Worcester Park, Surrey, have been appointed London agents for The Clyde Structural Iron Co. Ltd., of Scotstoun, Glasgow, who supply structural steel and other platework, roofing, bridging and similar components. This appointment is principally directed to supplying structural steel for the petroleum, petrochemical and chemical industries here and abroad.

LARGE PLATE STRETCHER FOR JAMES BOOTH

A LARGE plate-stretching machine has been ordered by James Booth Aluminium Ltd., from Fielding and Platt Ltd., Atlas Works, Gloucester. The machine, which will be in operation early next year, will cost approximately £150,000. It will be used for flattening aluminium alloy plates for use in shipbuilding, transport industry and various other engineering applications. The maximum length of plate which can be handled on the new 144 in. wide machine, is 50 ft., and the maximum thickness is one inch.

The ordering of the stretching machine is the latest step in the company's current £5 million modernization and expansion programme, and will be used in conjunction with the 148-in. four-high hot reversing mill—the largest of its type in Western Europe—which is now being installed at the Kitts Green Works, Birmingham.

HIGH-PURITY MERCURY AVAILABLE IN TWO GRADES

JOHNSON MATTHEY AND CO. LTD., announce that, following the installation of new equipment, they are now able to offer in quantity two grades of mercury for laboratory and industrial use. Redistilled mercury has a maximum impurity content of five parts per million (mostly copper and silver), and triple-distilled mercury a maximum of one part per million. Every batch is examined spectrographically to ensure that the limits are not exceeded. The metal is supplied in 7, 14, or 28-lb. containers, though other packings can be provided.

The product is described in a newly-issued data sheet in the Electrical Engineering series, 1300 : 492. Full details of prices and deliveries will be supplied on request to the company at 73-83 Hatton Garden, London, E.C.1.

SUBSTANTIAL CONTRACTS GIVEN FOR STEELWORKS PLANT

ORDERS amounting to approximately £2,000,000 have recently been placed with The Wellman Smith Owen Engineering Corporation Ltd., for steelworks plant and equipment. These contracts include rolling mill plant to the value of £750,000 (approx.) secured under the collaboration agreement entered into a short time ago between Wellman and Schloemann A.G., the well-known German rolling mill engineers.

Recent Wellman contracts also include an LD/AC oxygen steelmaking unit for Stewarts and Lloyds Ltd., Corby, under the Wellman-VOEST agreement, including the supply of heavy duty cranes.

Wellman have also received a £270,000 contract from Shelton Iron and Steel Ltd., of Stoke-on-Trent for mill cranes required to be available for erection and servicing of their new rolling mills.

SITE SHOTBLASTING

BACKED by over seventy years shotblasting experience and the resources of the Staveley Coal and Iron Co. Ltd., group, the Birmingham firm of R. J. Richardson and Sons, Ltd., is now operating a mobile site shotblasting service throughout the U.K. By utilizing the varied experience gained from contract work in its shops since 1890 and making a substantial investment in mobile plant, it has been possible to ensure that consistent standards of finish can be obtained on site which are fully equal to those carried out in a permanent shotblasting installation.

The equipment employed is transported to sites on one 7-ton B.M.C. truck and one Bedford 7-ton four-wheel drive truck, each towing a 7-ton, four-wheel trailer. The trailers carry the power units for the equipment, the first carrying a Leyland/Brush 90 kVA diesel generating set for the operation of driers, recovery plant and dust suppression units, while the second transports a Consolidated Pneumatic type 600-RO-2 Rolls-Royce powered rotary "Power Vane" compressor which delivers 600 c.f.m. of compressed air at a working pressure of 105 p.s.i., for the Tilghman shotblasting equipment, this comprising shot feeding equipment, hoses, guns and recovery plant.

£650,000 AUSTRALIAN ORDER FOR CLEARING PRESSES

AN order in excess of £650,000 has been obtained from General Motors-Holden's of Australia by Clearing division of U.S. Industries Inc.

Three large double-action presses, to a total value in excess of £250,000 sterling, will be manufactured in England under the normal manufacturing arrangements with Vickers-Armstrongs (Engineers) Ltd., at Newcastle.

Seven large single-action presses and four welding presses, to a total value in excess of £400,000 sterling, will be manufactured in Australia under normal arrangements with Vickers-Ruwolt (Pty) Ltd., Melbourne.

IPSEN INDUSTRIES FORM BRITISH COMPANY

IPSEN INDUSTRIES INC., of Rockford, Illinois, in association with Ipsen Industries International G.m.b.H., of Kleve, West Germany, manufacturers of atmosphere and vacuum automatic heat treating equipment and associated plant, have formed a British company, Ipsen Industries Ltd., 53, Victoria Road, Surbiton, Surrey, to facilitate further expansion of sales and service in Great Britain. Mr. L. E. Plimley, A.M.I.E.E., has joined the British staff and operates from 38, Monckton Road, Quinton, Birmingham 32 (Woodgate 4941).

MR. G. W. LACEY C.B.E., B.Sc., F.R.I.C. ELECTED PRESIDENT OF ALUMINIUM DEVELOPMENT ASSOCIATION

MR. GERALD LACEY

THE Annual General Meeting of the Aluminium Development Association was recently held at 33 Grosvenor Street, London, W.1, when the Annual Report was accepted.

The report was presented by Mr. W. Brining, the retiring president, who in the course of his introductory comments referred to the satisfactory continuance of the Association's work in the directions of research, development and information during the period reviewed.

The new president for 1961-62 is Mr. G. W. Lacey, C.B.E., B.Sc., F.R.I.C., assistant managing director (overseas) of The British Aluminium Co. Ltd.

Mr. Gerald Lacey was with Lever Bros. Port Sunlight Ltd. from 1914 to 1928, except for war service 1915-19, and for the next nine years he was with the Birmingham Aluminium Casting (1903) Co. Ltd. In 1937 he began his long career with The British Aluminium Co. Ltd., interrupted, again for war service, in the second World War when he seconded to the Light Metals Control of the Ministry of Aircraft Production, as Controller of Light Metals. In 1945 he returned to The British Aluminium Co. Ltd. as a director. The C.B.E. was conferred in 1946. Mr. Lacey served as a member of the Council of Industrial Design from 1947 to 1959.

The new president was a member of the executive committee of the Association from 1945-59 and served as its chairman for two years. Since 1959 he has been a member of the Council of the A.D.A.

On relinquishing the presidency of the Association Mr. W. Brining, F.C.A. (representative of the Almin group of companies on the Association's Council), was appointed vice-president.

In consequence of the resignation of Mr. G. Meredith from the Executive Committee, Mr. R. T. Raven (Birmetals Ltd.) was appointed chairman of the Executive Committee. Mr. P. S. W. Swabey (general manager of development, The British Aluminium Co. Ltd.) was appointed to the Executive Committee following the resignation of Mr. G. A. Anderson of the same company.

A NEW POST-GRADUATE COURSE IN WELDING TECHNOLOGY

THE Institute of Welding announce the organization of a post-Graduate Course in Welding Technology which the Ministry of Education has set up in response to the representations of the Institute of Welding and the British Welding Research Association at the College of Aeronautics, Cranfield; this Course will open in the Autumn of this year.

Already, the minimum enrolment to ensure the holding of the Course has been secured as a result of promises from A.E.I. (Manchester) Ltd., British Oxygen Co. Ltd. and Whessoe Ltd. The British Oxygen Co. has also promised to endow two Bursaries for a period of seven years, the candidates to be selected by the Institute.

In the U.S.A. and in the U.S.S.R. provision for the education of welding specialists is of long standing, so that the supply of qualified men far exceeds what is available in this country. This new course is, therefore, a most important development.

METALS DIVISION FOR DEWRANCE

DEWRANCE and Co. Ltd. announce the formation of the Dewrance Metals Division. This will consist of the foundry at Hillington and the special alloys division in London. The new division will have its own board of management and will be responsible for the production and sales of high quality non-ferrous castings, nickel alloy castings, stainless-steel castings, "Endewrance" hardfacing and high temperature brazing alloys. The production executive is Mr. J. B. Morton situated at Hillington, and the sales and technical executive is Mr. E. Wallace situated in London.

Merger of Furnace Manufacturers Announced

THE merger of The Incandescent Heat Co. Ltd. and its subsidiaries with the Wellman Group has now taken effect, and although it is the intention that the Incandescent Group shall continue to operate as an autonomous unit, the future close co-operation between these two groups should be mutually beneficial, as their products are mainly complementary.

Both Wellman and Incandescent construct furnaces for the metallurgical industries, but whereas Wellman specialize more on the larger melting furnaces and oxygen steel-making processes, including the heavy-duty mechanical equipment, the Incandescent Group's activities are, in the main, concentrated on the finishing processes of steel and non-ferrous products such as annealing and heat-treatment furnaces embodying a wide range of thermal engineering throughout the metallurgical, chemical, foundry, ceramic, and other industries. Incandescent specialities also include electric furnaces for melting and heat-treatment processes.

In their field, Wellman are specialists in the design and manufacture of furnace charging and discharging machines and thus the combined spheres of operation of the two companies will be enlarged.

In the export field for integrated steel plants, the two companies with their joint resources will be in a position to undertake the whole of the furnace work from steel melting including electric furnaces down to the smallest finishing and heat-treatment units.

NEW PLANT and EQUIPMENT

A monthly review of new machines, equipment, processes, etc., of interest to the producer and user of sheet metal

Die Spotting Presses

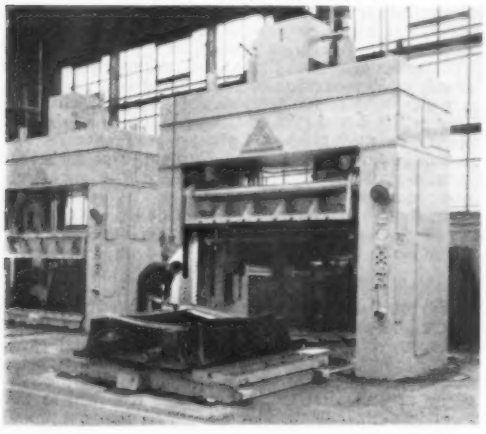
SPECIAL die spotting presses are used in the finishing of large press tools, especially in the motorcar industry, and requirements from these machines can vary very widely. Years ago toolrooms frequently had to make use of discarded production presses for this purpose, but this procedure proved unsatisfactory for many reasons.

A die spotting press should first be provided with an extremely sensitive control system, and it is further important that its movement should be very accurate, *i.e.* the table should be truly parallel to the ram at all times. Both these requirements, for obvious reasons, cannot be provided reliably on a machine which is no longer good enough for production, and indeed even a new machine for production would not normally offer the first of these features.

In addition to this a new production press would not be economical for this purpose since the pressure required on a die spotting press is almost negligible compared with that needed on a production machine. It is also essential for a die spotting press to offer a very high degree of safety, as work frequently has to be carried out underneath the ram.

In addition to the above essential requirements, particularly where very large tools are to be considered, it is desirable to make it easier to take tools in and out of the press, or alternatively, particularly on smaller machines, to have a press which is of sufficiently low initial cost for it to be possible to leave a tool in the machine for a long period and to have a large number of presses in use.

Fig. 1.—*Die spotting presses*



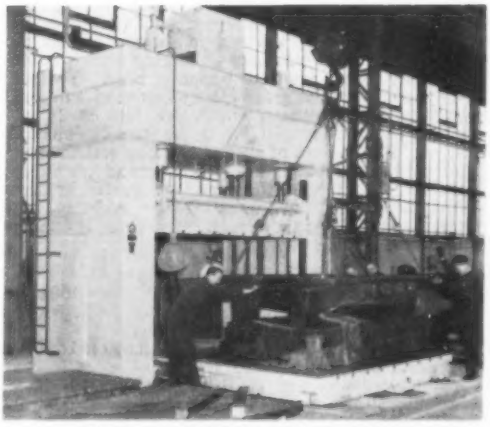


Fig. 2.—*Bringing the tool into the press*

To ensure a long working life for the machine, all moving parts must be well protected from the effects of grinding dust.

SMG of Wiesental (near Karlsruhe) are now building a variety of types of die spotting presses for these different applications and one of these types (of which two examples were recently delivered to a firm in the U.K.) is described below.

The two machines are shown in Fig. 1. An outstanding feature of the design is the arrangement of the table which can be moved out of the press hydraulically to facilitate bringing the tool into the press (*see* also Fig. 2) and this is also convenient for work on the tool itself, *i.e.* grinding can be carried out with the table in the outward position.

The machine is fitted with an axial piston pump which in this instance is particularly useful, to provide very sensitive infinitely-variable speed control. The farther the vertical hand lever (which can be seen on the right-hand side of the machine in Fig. 1) is pressed towards the right, the faster the ram descends. Before the lever can act, however, the horizontal safety lever has to be depressed to move out of engagement of the safety scotching device, which is in the form of a toothed rack (seen in the middle of the righthand press upright in Fig. 2). This scotching device positively prevents the ram from dropping unless the safety lever is held down.

For safety there are a variety of other electric interlocking devices to ensure that, for example, the ram can only be brought down when the table is in position. Since no heavy pressures are required it would be uneconomical to fit a ram of conventional proportions so that it is not necessary to provide long guides on the ram. In order to ensure that the ram will always remain parallel to the table, racks and pinions are provided at each end connected by a shaft. A further feature of these presses is the provision of "hard stops." Screws are attached to the four corners of the ram and the nuts on these provide a positive limit to the downward movement. The nuts are turned through a motorized drive and can be adjusted to give a precise figure in the distance between table and ram when the ram is in the "down" position; the value being indicated on the large dial set at an angle on the righthand press upright. This dial is calibrated in 0.002-in. units.

The frame is of welded construction in four parts rigidly held together by pre-tensioned anchor columns; all components are normalized before machining. The ram guides are lined with a hard plastic material which has proved itself over a long period of time to possess first-class slide properties and to show a minimum of wear and complete resistance to scoring even if allowed to run dry for an extended period of time. The press cylinders are of high grade electro-cast steel and honed internally. The pistons, which are also made of a specially selected material, are in the form of differential pistons. Piston rings of special cast iron seal the piston head in the cylinder. The finely-ground piston rods have a high surface hardness and are guided in bronze bushes and sealed by means of wear resisting, easily interchangeable, special sleeves. The press is equipped with a manual control system.

Dimensions are as follows:—

Maximum pressure	100 tons
Distance between uprights ..	2,800 mm.
Size of table and ram face, left to right × front to back	2,800 × 1,930 mm.
Maximum distance between ram and table	1,780 mm.
Maximum stroke of ram	1,220 mm.
Power required	25 h.p.
Maximum speed of ram:	
with pressures up to 40 tons ..	46 mm. per sec.
,, ,, 60 tons ..	34 mm. per sec.
,, ,, 80 tons ..	24 mm. per sec.
,, ,, 100 tons ..	19 mm. per sec.
Maximum return speed	125 mm. per sec.
Maximum return pull	40 tons

U.K. agents for SMG Presses are Pearson Panke Ltd., 3, Hale Grove Gardens, London, N.W.7.

Multiple Die Punching Machine

THE essential idea behind the design was to produce a machine (Fig. 3) which can perform any conceivable punching, shearing or notching operation (within the capacity of the model), by utilizing different interchangeable heads, which can each be tooled for a particular job. The time taken to change tools is thus only a matter of seconds; it is necessary only to move one handle, which operates a quick-action cam clamp. Interchangeable heads are available for punching; fitted with shearing tools for flat, round, square and sectional stock; and others fitted with square notching tools and mitre notching tools. Special punches or tools can be supplied for many industries. The tools, having once been set in the interchangeable head, need not be re-set when being replaced in the machine for further use, so that many tool changes can be accomplished without expensive setting times.

This type of machine is claimed to have great advantages, not only for high production set-ups, whereby two, three or more machines can be laid down and continuously worked, with only one complete set of quick-change tool heads to feed them, but also for small jobbing production, where the requirement is constantly changing. Further advantages claimed are the concentrated work load, and the small floor space required.

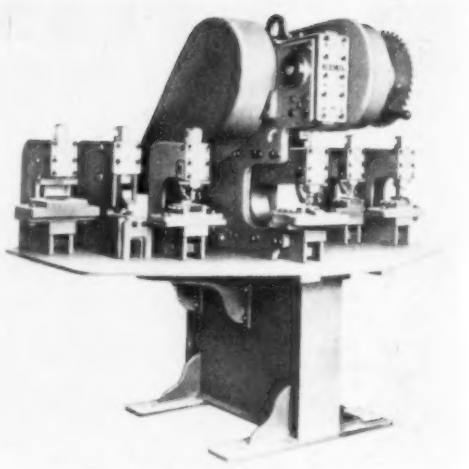


Fig. 3.—Die punching machine

The machines are of sturdy all-steel fabricated construction. Drive is from a star delta motor to a balanced flywheel, through transmission shafts running in roller bearings to completely enclosed gear reduction, driving the eccentric shaft which operates the ram. The gear reduction equipment runs in an oil bath, and the eccentric shaft is mounted in special bronze bearings. The ram is hardened and ground and the extra long ram guides are adjustable. The multi-tooth dog clutch is also hardened and ground, and engagement of the clutch can be effected by treadle or hand operation. The ram can be raised and lowered by handwheel, with or without the motor running. When it is necessary to punch out according to markings or centre punch location, this can be accurately located by hand without movement of the work when depressing the clutch pedal or hand lever. All component parts subject to heavy stresses, such as eccentrics, pressure plates, clutch gear, etc. are hardened, and the main bearings are made from special hard bronze. The oil bath casing is fitted with a filler and a drain plug, and lubrication points are provided where necessary.

The range comprises five models, commencing with a capacity of 35 tons pressure, with throat depth of $7\frac{1}{4}$ in., up to a capacity of 100 tons, with $13\frac{3}{4}$ in. depth of throat. The smallest model (Vm 35/200) will punch a $\frac{3}{4}$-in. dia. hole in $\frac{1}{2}$-in. thick mild-steel plate; or alternatively a 2-in. dia. hole in $\frac{3}{16}$ mild-steel plate. Cropping capacity is 1-in. dia. mild-steel bar, and $2\frac{3}{8}$ in. × $2\frac{3}{8}$ in. × $\frac{1}{16}$ in. angle iron. Larger machines can be supplied to special order.

Distributors for Edel equipment in the United Kingdom are F. J. Edwards Ltd., Edwards House, 359-361, Euston Road, London, N.W.1.

Hydraulic Shaving Press

THE standard Norton press hitherto used principally for high-speed blanking and dieing has been developed to provide yet a further function—that of high-speed vibratory shaving (Fig. 4). The main control unit is set to provide vibratory ram action, and use is made of the feature of pressure-sensitive return of the ram, so that each down stroke of the ram is returned against a pre-set

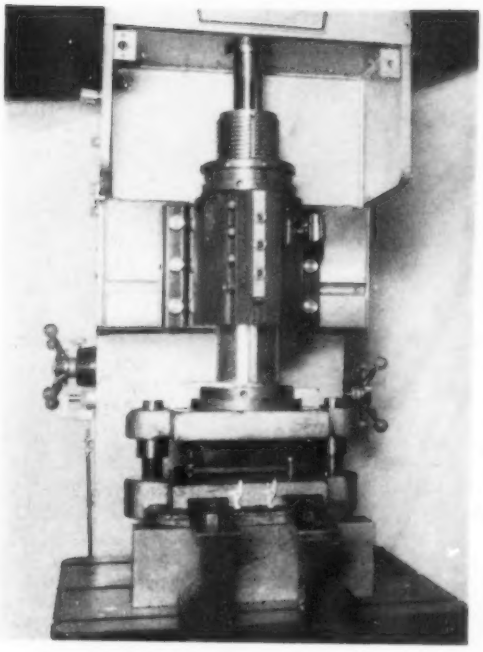


Fig. 4.—Hydraulic shaving press

pressure which itself is steplessly adjustable. Adjustment of pressure determines the depth of section shaved with each vibratory stroke, and consequently the number of shaves or " cuts " per component may be varied to obtain the best finish.

The final ram stroke is limited to a setting accuracy of ± 0.0005 in. by the ram dead stops and the amplitude and frequency of the vibrations is adjusted by the setting of the main control.

Of considerable significance is the ability to vary the ram speed and consequently the cutting speed of the shaving tool. It is possible therefore, to set the correct cutting speed for the material of the component being shaved.

The rate of vibratory strokes may be varied from under 1,000 to approximately 1,800 per min. and the shaving time for the component used in the demonstration, namely a computer key of 0.090 in. carbon steel, was approximately three-quarters of a second. Surface finishes of 4 to 6 microinches are possible.

This is claimed to be the first British vibratory shaving press and the variations available in setting the number of shaves per section, the speed of the shaving action and the frequency of the vibrations provides several advantages. Assuming metal removal of 0.005 in. the shaving capacity of the press is expressed as a maximum periphery of 20 in. on material of 30 tons tensile strength.

Sole world concessionaires of this machine, which is wholly British designed and British made, are Frank Lewis and Co. (London) Ltd., 65, St. Pauls Churchyard, London, E.C.4.

Portable Electric Drill

A PORTABLE electric drill (Fig. 5) developed in America, which can be used independently of mains supply or power cable was demonstrated recently by

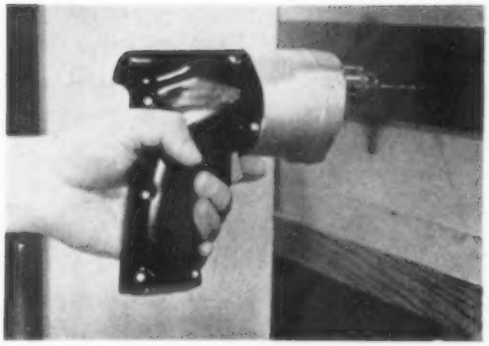


Fig. 5.—Portable electric drill

Black and Decker Ltd., Harmondsworth, Middlesex. Very little technical data about the power source was available except that it combines a series of power cells with a motor radically different from any previous model. As the tool is still in the "one off" stage, few figures are available about its performance. The company estimate that the drill can produce 75 $\frac{1}{2}$-in. holes in $\frac{3}{4}$-in. wood or 75 $\frac{1}{4}$-in. holes in $\frac{1}{4}$-in. steel plate before it needs re-energizing. The power cells can be recharged 400 times before a new power unit is needed. The charging is effected by plugging the drill into the mains supply. In its present form and with the information available the impact this piece of equipment will make in industry is difficult to estimate, but the principle is a major break-through in modern power tool design and future research and development will no doubt produce power tools with almost unlimited applications.

Magnetic Crack Detector

THE " Portamag 850 " magnetic crack detector was introduced at the Engineering, Marine, Welding and Nuclear Energy Exhibition, by Research and Control Instruments Ltd. with the unique feature of a thumb switch mounted on one electrode for controlling the 850-amp a.c. output current. This thumb switch operates a 12-volt relay in the primary circuit and gives press-on, release-off control.

Other features are a large clear reading ammeter to indicate that current is flowing, mains indicator lamp, and ample storage space for the 6-ft. cables within the weather-proof case, which is finished in hammered grey.

The " Portamag 850 " is supplied for 240v a.c. mains and its consumption is 10 amps. Dimensions are: height 10 in., width 9 in., length 14 in., weight 45 lb.

Further information is obtainable from Research and Control Instruments Ltd., 207, Kings Cross Road, London, W.C.1.

Seam-welder Blanks

JOHNSON MATTHEY announce that a wider range of rough-machined seam-welding wheel blanks in Mallory 3 can now be supplied from stock.

In the interests of international standardization, the blanks are now available in metric sizes, as recommended in B.S. 3067. The new range includes all the commonly used sizes listed in the specification, and the metric sizes are very close to the superseded inch sizes.

Details of the new range of sizes are given in leaflet 7200/3, " Resistance Welding Electrode Materials," obtainable freely on request to the company, at 73-83, Hatton Garden, London, E.C.1.

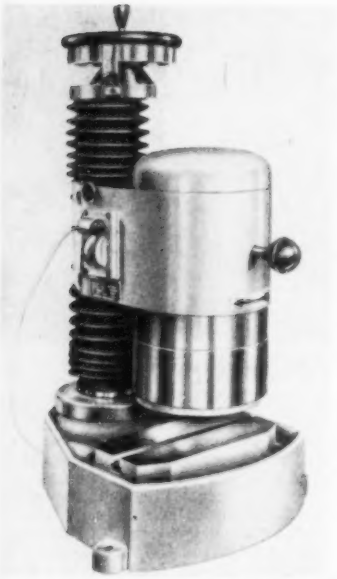


Fig. 6 (left).—Precision surface grinder

Fig. 7 (right).—Press with broaching device

Precision Surface Grinder

FIG. 6 shows a small hand-operated surface grinder, produced by the H. G. Stevens Co. Ltd., 16 Coverdale Road, London, N.W.2, which can deal with diameters up to 7¾ in. and with rectangular areas of up to 6 in. by 12 in. and 4 in. by 16 in. A first class finish (flat or hollow-ground to choice), is claimed to be due to the rigid construction of the machine and the fact that the 3-h.p. three-phase motor and the grinding spindle are dynamically balanced as a unit. The high-frequency hardened grinding spindle is more than 1½ in. thick and the main pillar diameter is over 3½ in. The vertical feed scale is optically magnified and calibrated in units of ¼ "thou".

Hydraulic Presses and Broaching Device

BROADWAY EQUIPMENT LTD., of Parway House, 194/196 Finchley Road, London, N.W.3, are agents for the M.A.E. Hy series of hydraulic presses and the M.A.E. special broaching device, produced by Maschinen-und Apparatebau G.m.b.H., Erkrath. The Hy presses are produced in table models of 2.5 and 6 tons, and column models of 6, 10, 16, 25, 40, 63 and 100 tons and more ; they have high versatility and can be operated by unskilled labour. The M.A.E. broaching device enables the downward movement of the ram to be changed into a drawing movement so that the broach is pulled and not pushed through the workpiece and has the added advantage of automatic broach transfer whereby the broach is transferred automatically from a bottom broach holder to the top broach holder after the broaching operation takes place, thus eliminating the hand setting of broaches. Fig. 7 shows the Hy-S-16ZR 16-ton model with the broaching device mounted.

Multi-specimen Creep Testing Machine

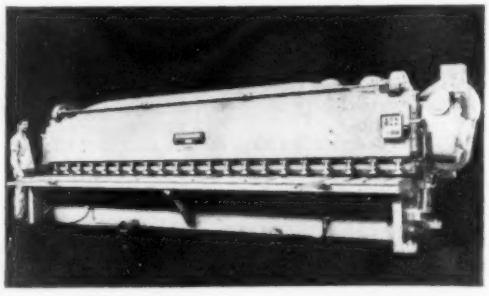
THE United Steel Companies Ltd. have designed a compact creep testing machine which is now being built and marketed by the Distington Engineering Co. Ltd. of Workington, Cumberland. The machine is designed to accommodate either four high-sensitivity tests or twelve stress-to-fracture tests on the one machine, with one furnace and one temperature controller and incorporates four loading systems, each of which caters for one high-sensitivity test or three stress-to-fracture tests in series. The machine occupies a floor space of slightly more than one square yard and the complete unit comprises the creep testing machine itself, a furnace consisting of a fused silica tube wire wound in three zones for resistance heating and encased in a polished stainless steel cylinder, a control panel incorporating an electronic temperature controller and two auxiliaries—a ratchet spanner and lifting jack—which can be used with a number of machines. The machine can be used for the application of loads up to three tons on a specimen.

All-steel Shear

FIG. 8 illustrates the Cincinatti Series 4320S shear produced by the Cincinatti Shaper Co. of Cincinatti 11, Ohio, who have a subsidiary in East Kilbride, Scotland. The shear has a cutting capacity of $\frac{3}{16}$ in. by 20 ft. mild steel and is equipped with a 36 in. back gauge range. Back gauge adjustment is front controlled and power operated for quick, easy blank width settings. Automatic pressure lubrication, a long work chute at the rear of the machine, ball transfers in the table to facilitate plate handling, and hydraulic hold-downs are added features.

(*Continued in page* 476)

Fig. 8.—All-steel shear



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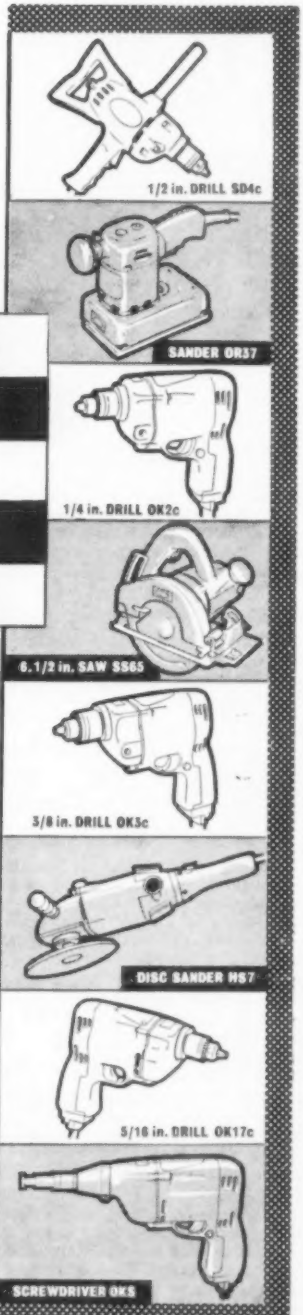

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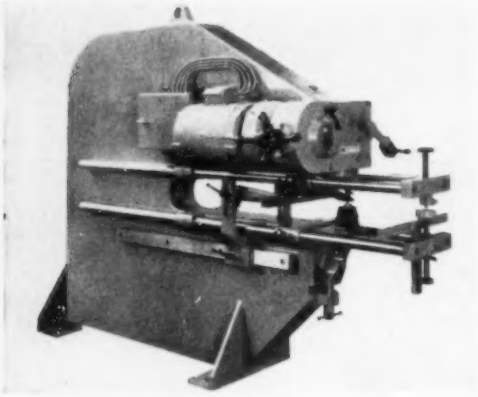


Fig. 9.—Nibbler and shearer

Nibbling and Shearing Machine

FIG. 9 shows Model NA.1200/9 Universal nibbling and shearing machine manufactured by Bachofen and Meier of Switzerland, for whom the Press and Shear Machinery Co. Ltd. of 172/178 Victoria Road, Acton, London, W.3, are the U.K. agents. The machine is capable of nibbling mild steel up to $\frac{3}{8}$ in. and forming, peening, louvring, flanging and folding up to $\frac{5}{32}$ in. A cutting attachment is supplied as standard equipment.

Wider Scope for Gravity Conveyors

A DEVELOPMENT that will open up new fields for gravity conveyor systems is announced by Dexion Ltd., manufacturers of the well-known slotted angle equipment. The new product is a specially treated nylon Glidewheel. Designed for operation without the bush assembly normally found in conveyor wheels it is weather-proof and non-corrosive, and lubrication and maintenance are eliminated. The material is hard-wearing and the wheel has a long working life. It is more economical than the earlier steel ball-bearing Glidewheel, which it will now replace, and is believed to be the most inexpensive wheel of its kind now on the market.

The nylon wheel retains all the advantages of its steel predecessor, which has enjoyed outstanding success in industrial plants all over the world: every conveyor can be tailor-made for the job; bends and curves cost no more than straight runs; length, width, height and load-bearing capacity can be varied.

The inertia of the $\frac{1}{4}$-oz. nylon wheel is improved over that of the previous ball-bearing wheel, and the more generous proportions (diameter 2.312 in.; width $\frac{3}{4}$ in.) afford a wider load-bearing surface, giving better tracking on shallow gradients and smooth, gentle conveyance for quite soft containers.

As with Dexion's earlier unit, the nylon version is designed for use in association with the company's range of slotted angle, but, being completely weather-proof, it now makes the permanent outdoor gravity conveyor a practical proposition—by using the new wheel in conjunction with Dexion's galvanized angle.

Some indoor conveyors, too, will be improved, where, as in laundries and processing plants, they would normally be subject to atmospheric or chemical corrosion. The wheel's operation is little affected by dust a point of vital importance in sawmills, bakeries, etc.

Leaflets are available from Dexion Ltd., Maygrove Road, London, N.W.6.

Filtration Unit for Spark Erosion

STREAM-LINE FILTERS Ltd. of Henley Park, Guildford, Surrey, have produced a filtration unit for use with spark erosion machines to ensure the cleanliness of the dielectric liquid; the construction of the machine is such as to enable filtration to be carried out either in batches or continuously. For continuous filtration, the unit is coupled directly into the spark erosion oil line in a closed circuit and the dirty liquid flows into the filter where it is cleaned and returned to the machine. For batch filtration, there are two 20-gallon tanks, the dirty one in the front and the clean one at the back, each with a separate motor-driven pump; the liquid in the dirty tank passes through the filter and flows into the clean tank ready for transferring to the spark erosion machine. A suitable metal drawer is situated at the base of the filter to catch the sludge when the filter is cleaned by blowing compressed air through the packs in the reverse direction.

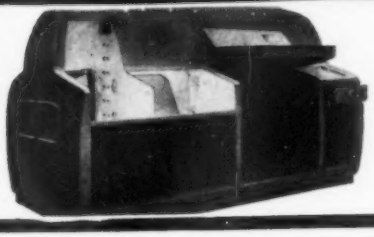
Metal Cutting and Circular Sawing Machine

THE Addison Tool Co. Ltd., Addison House, 28 Marshalsea Road, London, S.E.1, have introduced a new design of metal cutting and circular sawing machine, which is manufactured by the Etablissements Chalayer, 44 Rue, Ambroise-Paré, Saint-Etienne (Loire). The special design enables cuts to be made from the bottom upwards and considerably reduces the force required for cutting and makes it impossible to break the blade. A pivoting tray enables cuts to be made at all angles from 0 to 180 deg. without moving the bars to be cut, and adjustable back plates give full support to the workpiece at either side of the blade, facilitating burr-free sawing. The 12-in. H.S.S. saw blade rising from below the 360 deg. turntable cuts mitres without runout and permits maximum use of the saw blade for slotting, etc.; the saw head travels on a centre column giving straight cuts each time. Continuous lubrication is provided by an electric pump fixed on the frame. Operation of the machine is by a $\frac{1}{2}$-h.p. 1,500-r.p.m. electric motor.

Audible Thickness Gauge

FIG. 10 shows a portable thickness gauge produced by Metallisation Ltd. of Dudley, Worcs., which enables sprayed zinc and aluminium coatings to be checked quickly over large areas. The principle of operation is based upon an exploring head which may be moved over the coated surface and gives an audible warning of areas which are below the required thickness; the gauge can be set to any desired thickness between 0.002 in. and 0.012 in. The set is unaffected by magnetic fields or stray magnetism and the operational battery has a life of over four months.

Fig. 10.—Audible thickness gauge



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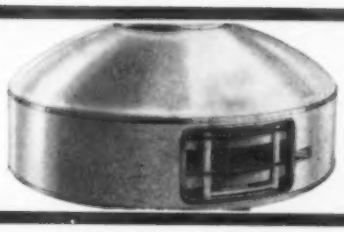

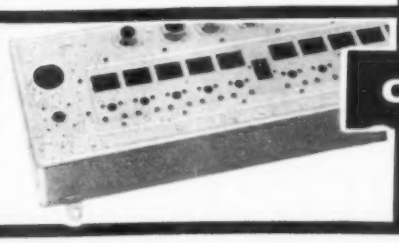

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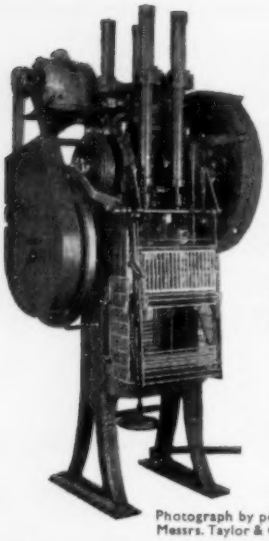

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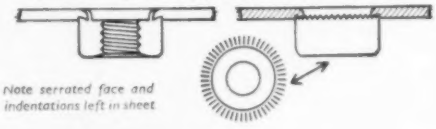

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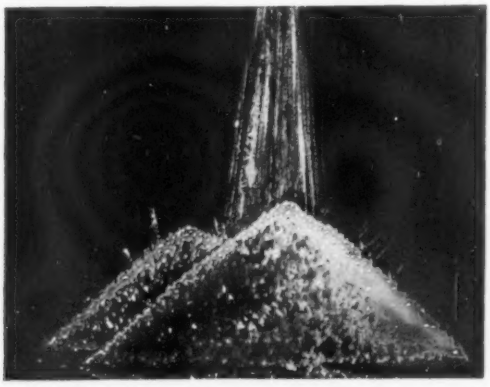

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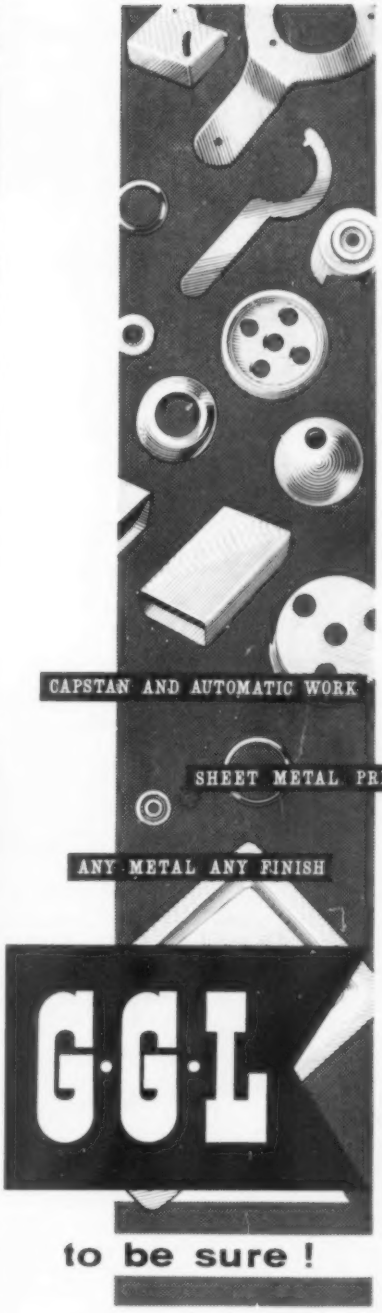

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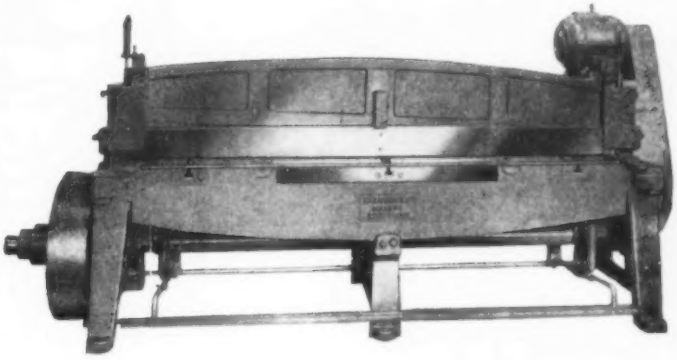

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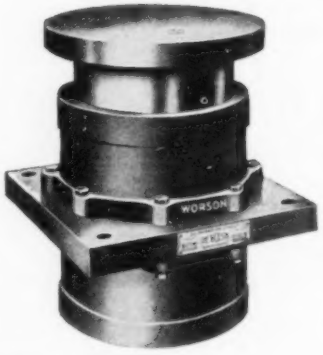

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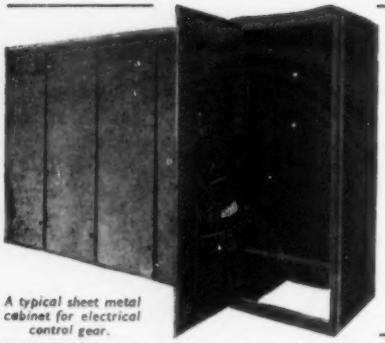

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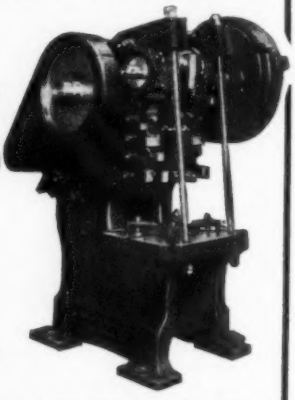

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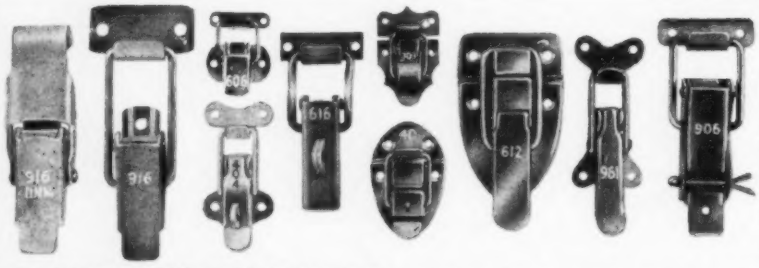

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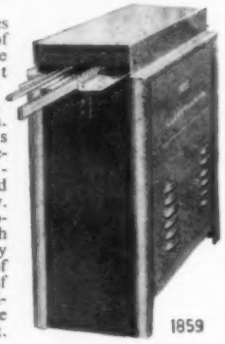

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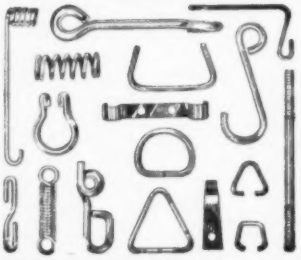

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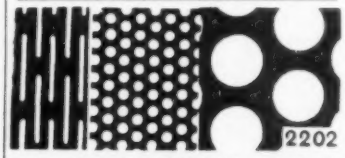

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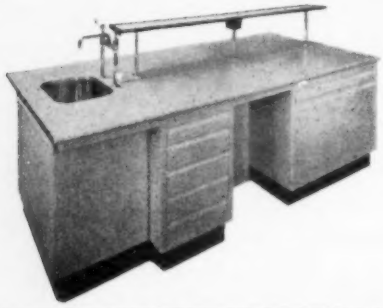

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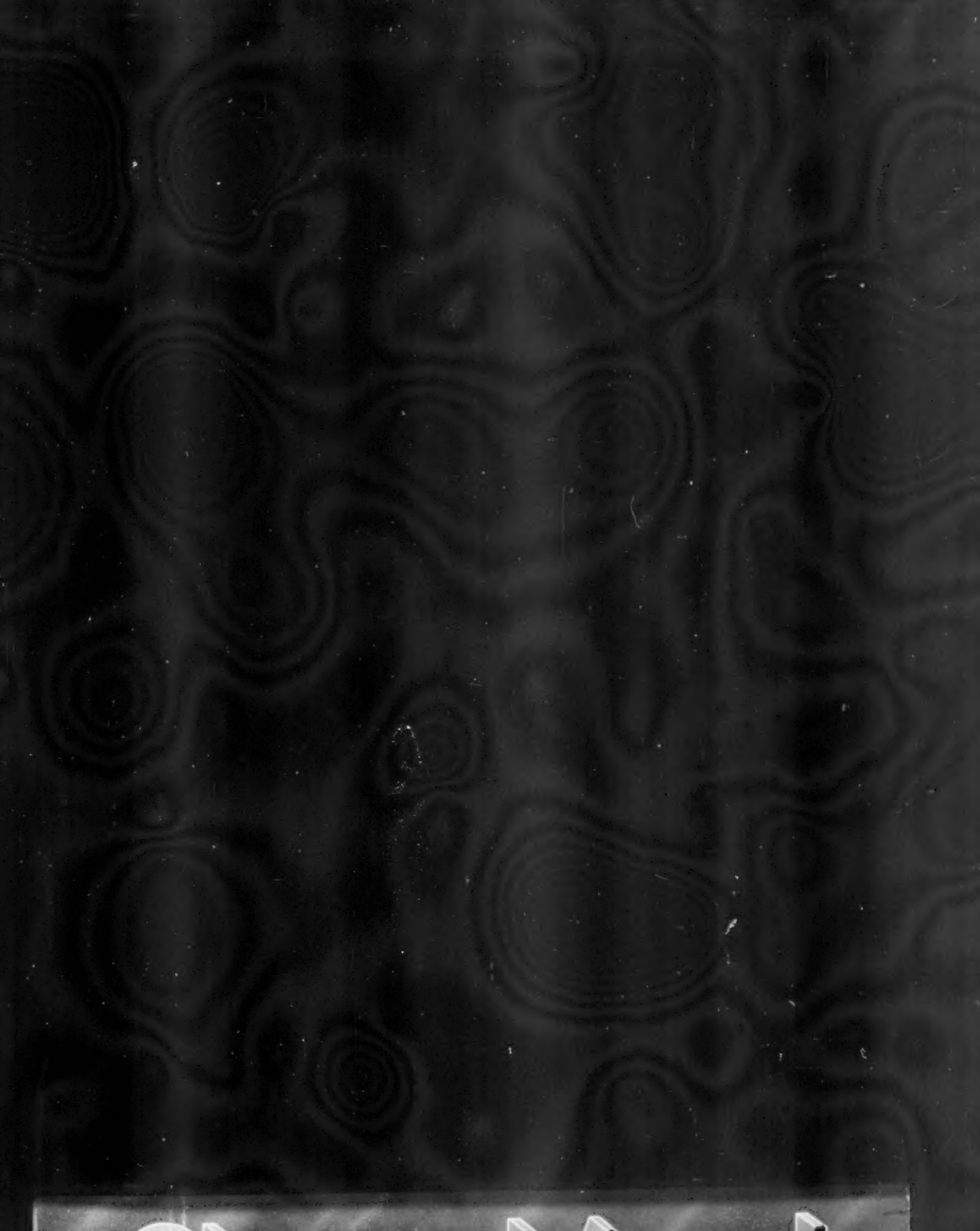
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